

13.1.4. Individual case

Agha G Hotel

【Judgment】

Restricted (Repair is needed)

【Measure】

Extended upper two stories should be removed.

All of the cracks in damaged columns and walls should be mended.

Madina Market

【Judgment】

Safe (It can be used)

Income Tax Office

【Judgment】

Some columns are destroyed and rebars of the columns are bare, but it was judged that they were possible to be mended and strengthened.

【Measure】

Candidate of strengthening method is shown in **1)**, **2)** and **3)** of following pages.

It is thought that the story drift more than the allowance was generated at earthquake. It is requested to provide the RC shear walls to control the story drift. Main point of adding shear wall is explained in **4)** of the following pages.

House

【Judgment】

Restricted (Repair is needed)

【Measure】

Re-strengthening of masonry building must be designed carefully. In this document a method based on the concept of “Confined masonry” is shown in **6)** of following pages.

Mir Muhammad Hussain

【Judgment】

Unsafe (to be reconstructed)

Mosque

【Judgment】

Unsafe (to be reconstructed)

Raza Hospital

【Judgment】

Restricted (Repair is needed)

【Measure】

Columns in an uppermost floor were destroyed severely. If the columns in an uppermost floor are strengthened and mass of that floor increase, larger inertia force will be transmitted to lower stories. At least an uppermost floor is to be demolished or replaced by lightweight material like as wood.

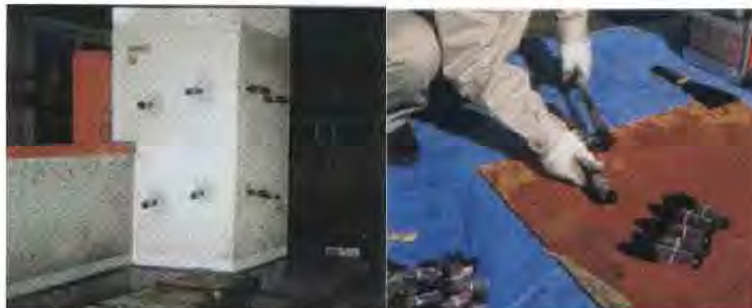
Regarding the seriously cracked column of middle story, careful measures must be undertaken.



It is thought that this crack caused by inappropriate drilling seen at this part. In addition there may be some defective construction of rebar arrangement. At least this column needs to be confined by using some kind of hoop jacketing. Various types of jacketing are shown in 7) of the following pages.

1) Repair of damaged column using epoxy injection

If the cracks in the column are not so large, epoxy injection can be applied. For instance some columns in “Income tax office” can be mended by epoxy injection.



Undertaking epoxy injection

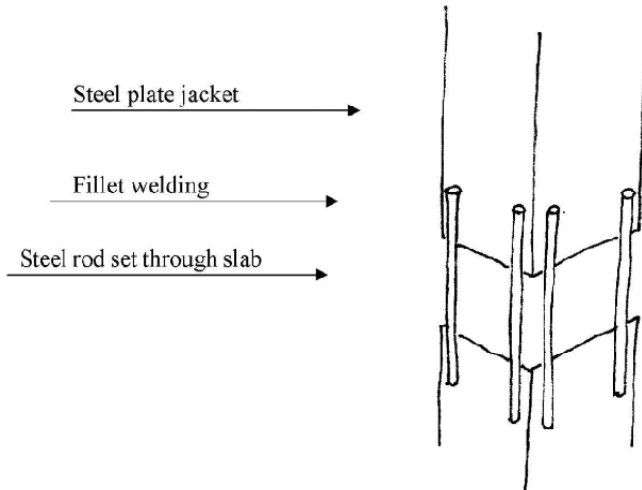
Tool of injection

Order of undertaking is as follows:

1. Confirm every crack
2. Clean inside surface of every crack
3. Seal the cracked part of structure
4. Inject polymer material

2) Repair of damaged column using steel plate jacket

If sufficient steel plate is available, then steel plate jacketing is applicable. Steel plate jacket shall be connected to that of upper story and lower story by steel rod when continuity of the column is not sufficient.

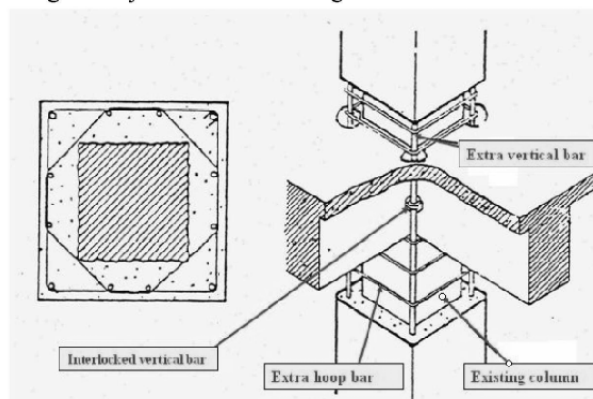


Order of undertaking is as follows:

1. Mend relatively large cracks of column
2. Set steel plate jacket
3. Drill hole in the slab
4. Set steel rod and connect by fillet welding
5. Inject cement-sand mortar or polymer material into the void between existing column and steel plate jacket

3) Repair of damaged column using RC jacket

This is a schematic drawing of RC jacket and connecting vertical rebar.



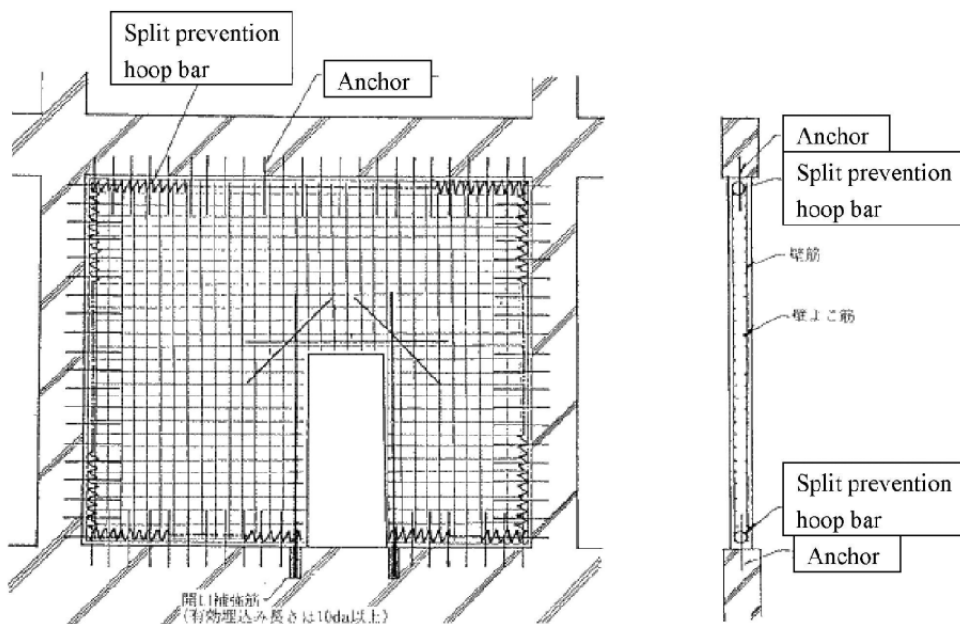
Order of undertaking is as follows:

1. Gets rough of surface of the existing column
2. Drill hole in the slab
3. Set vertical rebar and hoop bar
4. Set the form
5. Cast concrete

Keeping tight connection between jacketing concrete and existing slab and beam is needed.

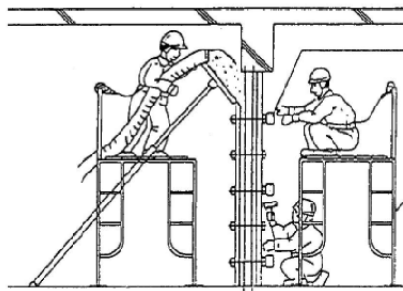
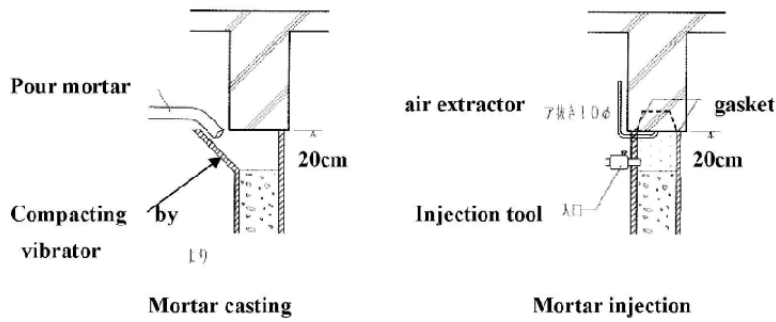
4) Adding RC shear wall

Adding RC shear wall might be the most effective re-strengthening method for many buildings in Muzaffarabad. Figure below shows an example that was undertaken in Japan.

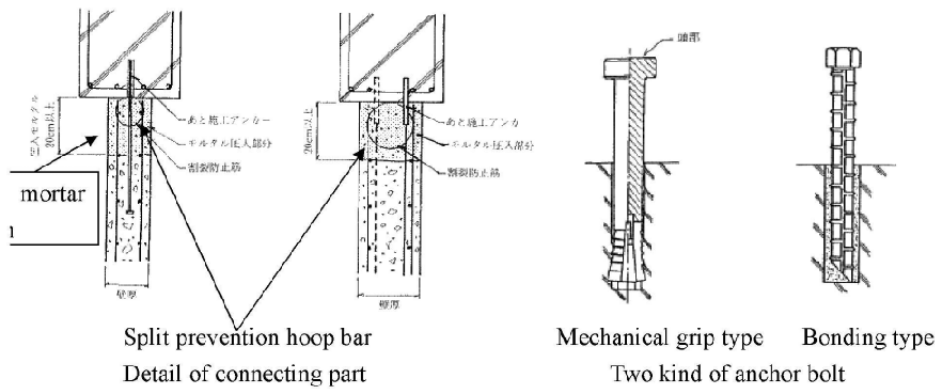


front elevation view cutaway view

Main point of this method is to keep tight connection between the wall and beam, (or column). Void tends to be generated because of shrinkage of cement mortar. If void is generated, effect of shear wall shall be impaired.



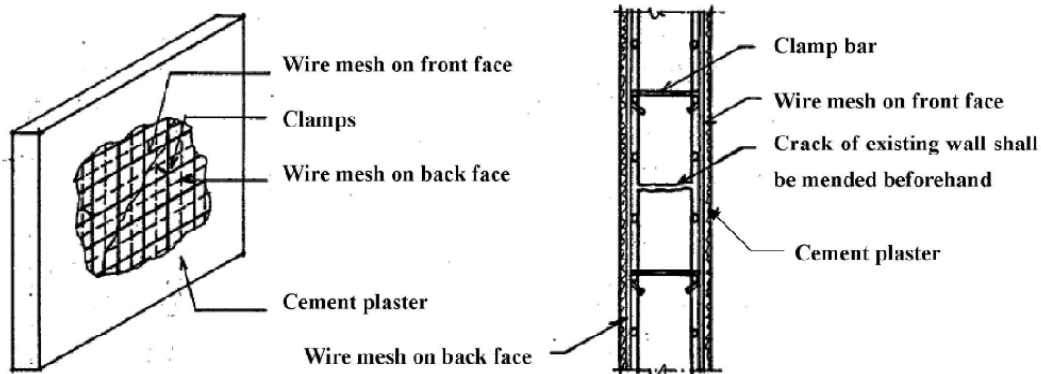
Anchor bolt is also indispensable. If there is no specific measure for connecting the shear wall and existing beam, wall shall collapse in out-of-plane direction. An example of anchor bolt and detail of connecting part is shown in below figure.



5) Wire mesh and cement plaster

When Adding RC shear wall is not available “Wire mesh and cement plaster” can be next best. Existing Brick wall can be used.

In this method clamp bar should be put in position carefully.



It may be more effective if shot blast concrete is used instead of cement mortar plaster.

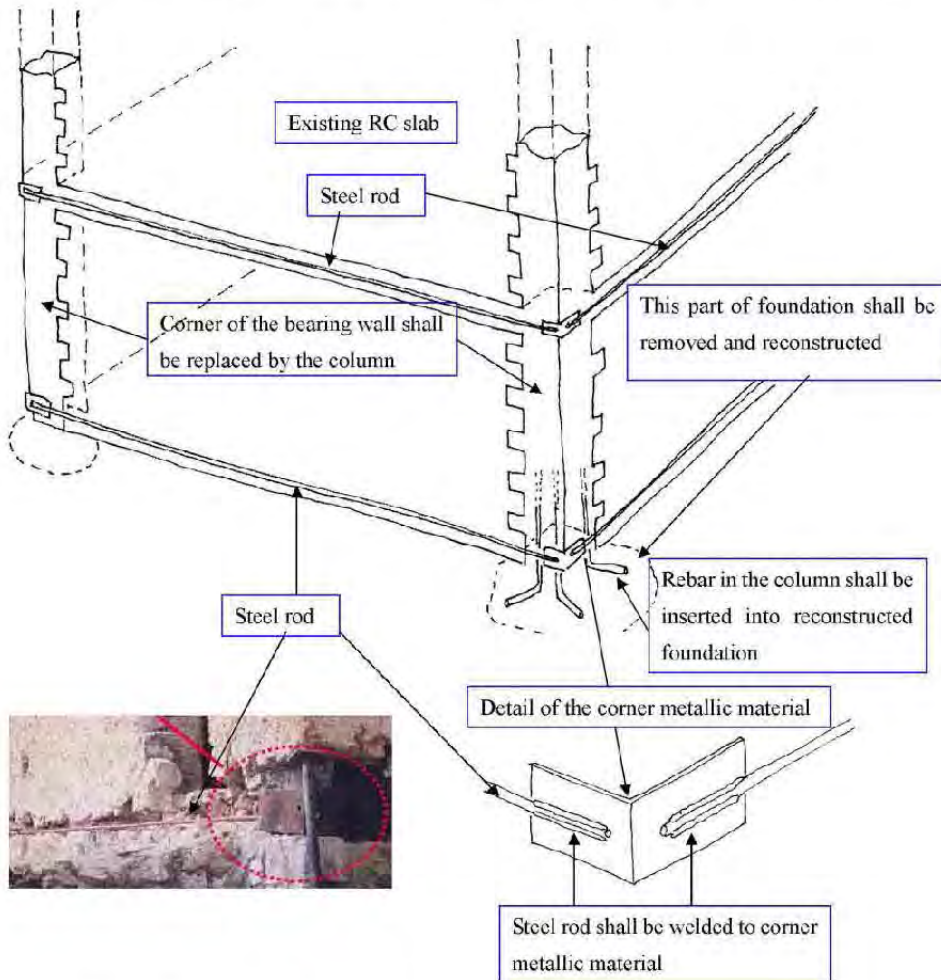


It is reported that this kind of measure is effective even for low quality brick as the photo below indicates. Welded steel wire mesh (1 mm wires spaced at $\frac{3}{4}$ inches) was used in this example. The mesh is placed in horizontal and vertical strips simulating beams and columns, and is covered with cement and sand mortar.



6) Confinement procedure of masonry building

Figure below shows a scheme of re-strengthening of existing un-reinforced masonry building. If the existing masonry building has RC slab, the following re-strengthening can be undertaken.



Order of re-strengthening procedure is as follows:

1. If bearing wall is cracked, every crack shall be mended by cement mortar grouting and cured in sufficient period
2. A corner of the bearing wall shall be removed carefully
3. A corner of foundation shall be removed carefully
4. Rebar shall be set (Rebar in the column shall be inserted into reconstructed foundation)
5. Form shall be set

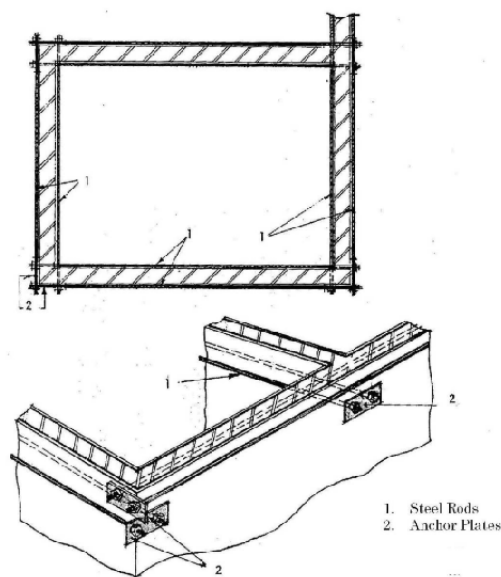
6. Cut surface of brick shall be wet
7. Fresh concrete shall be poured and cured in sufficient period
8. Above procedure shall be done at next corner
9. When all of corner is replaced, steel rod shall be set

Caution:

This re-strengthening method should be applied only for the buildings which have sufficient foundation with no ground settlement.

Removing and reconstruction of corner column should be done one by one. Do not undertake construction all at one time.

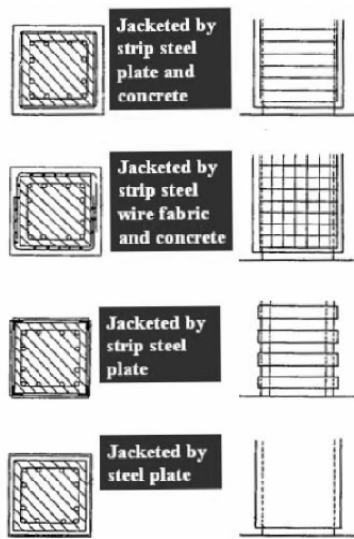
There can be another alignment of steel rod like as a figure shown in below.



Another alignment of steel rod

7) Various type of jacketing

Various type of jacketing are prepared to obtain confinement effect for column.



Candidate of various type of jacking

Jacking by carbon fiber



Polyester sheet jacking




Carbon sheet jacking

13.1.5. Main Points of Structures

(1) Main Point of RC structure

Main Point of RC Structure

The Urgent Development Study On Rehabilitation and Reconstruction
in Muzaffarabad City
in the Islamic Republic of Pakistan

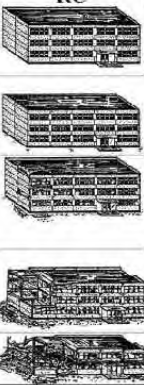


Essential Point of RC Structure

- Execution of structural analysis
- Dimension of columns and beam
- Column arrangement
- Rebar arrangement
- Foundation

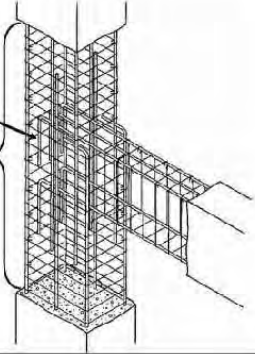
RC

Damage state and design criteria



Operational	Large story drift
Life safe	Destruction due to local failure
	Total destruction

Rebar arrangement

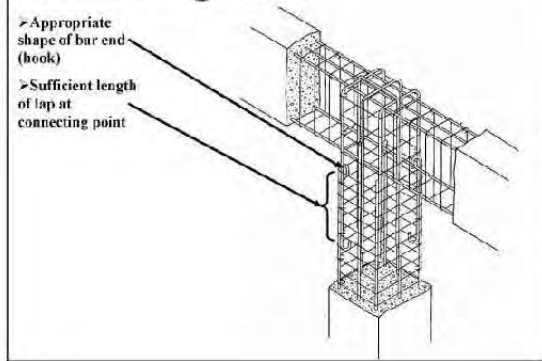


- Rebar of Beam must be connected to Column
- Rebar of Column must be continued

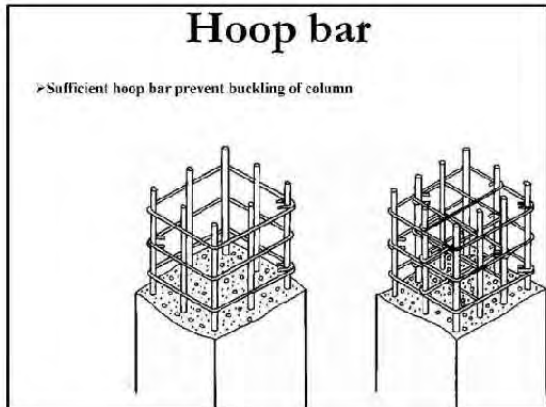
Otherwise



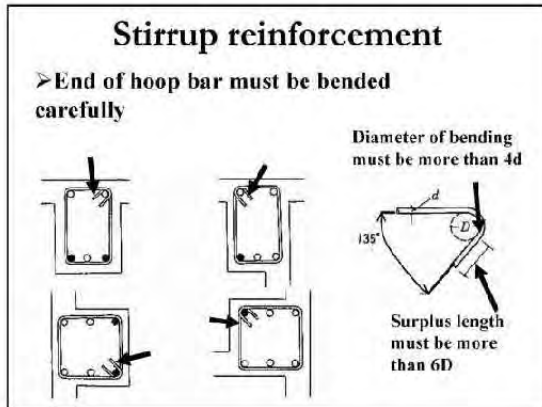
Rebar arrangement

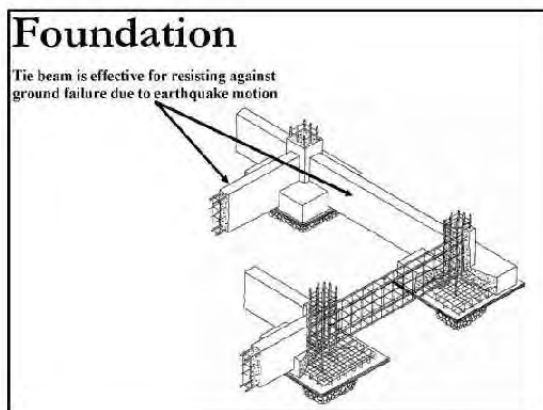
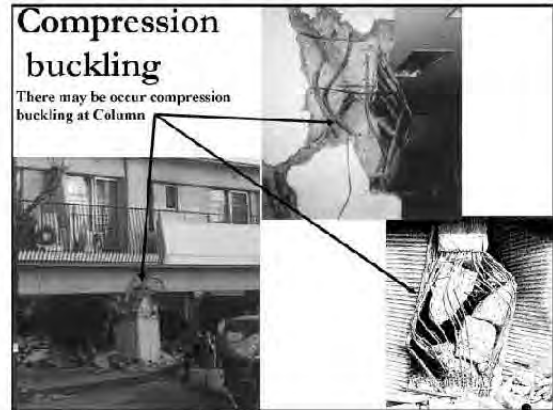
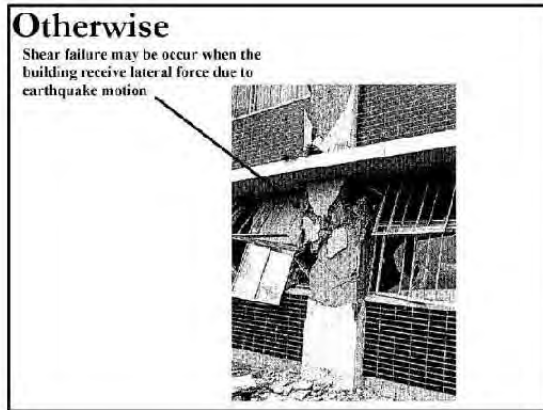


Hoop bar



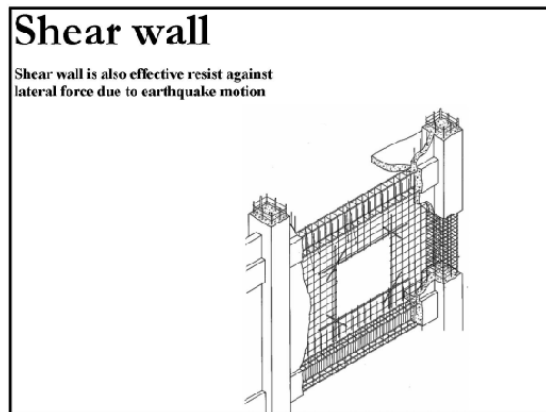
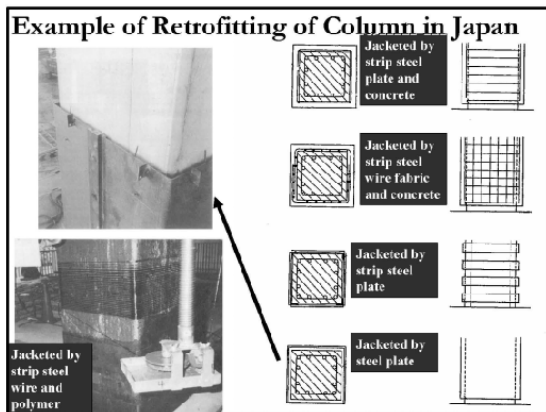
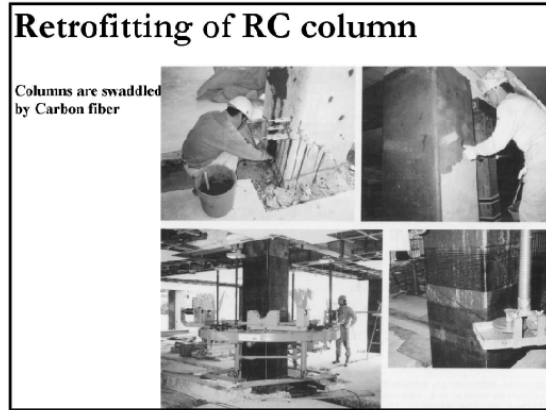
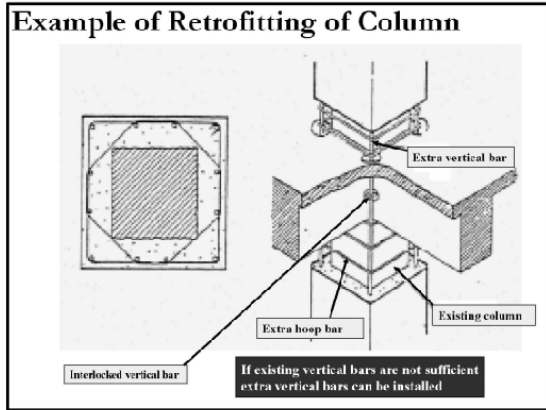
Stirrup reinforcement

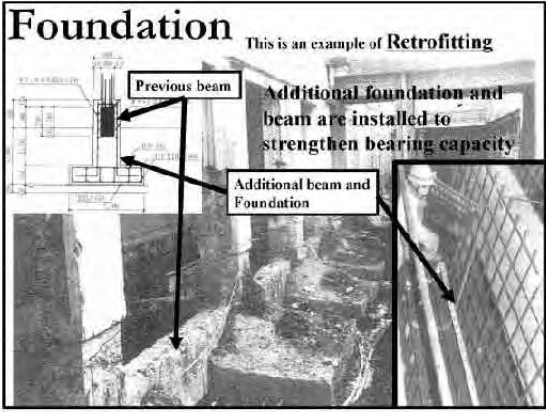
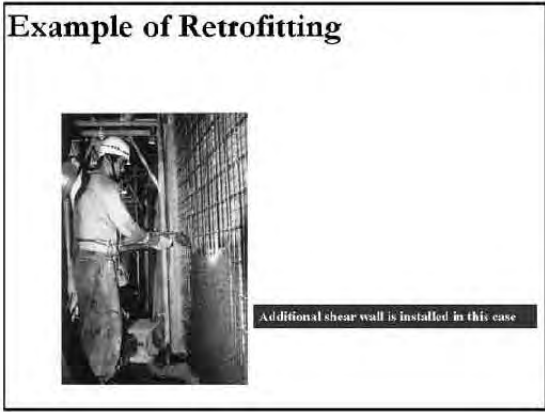
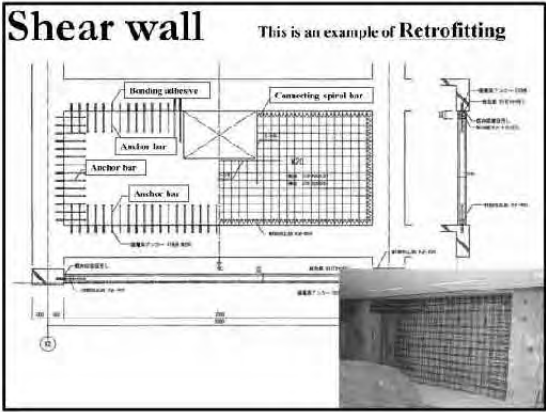




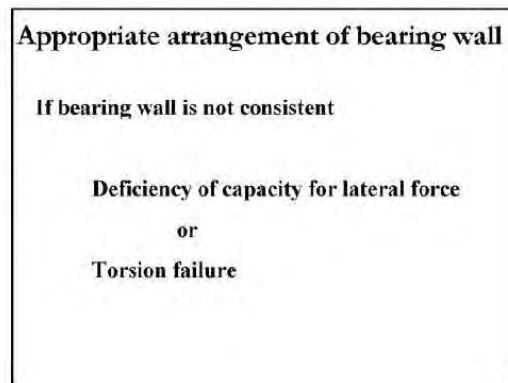
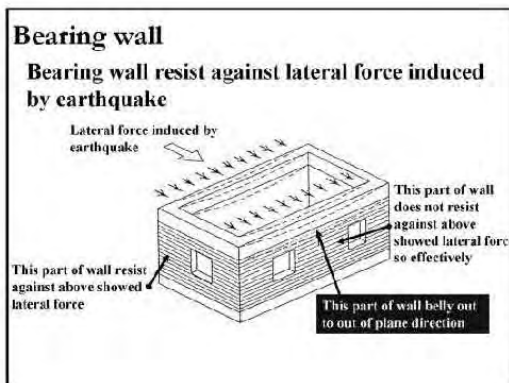
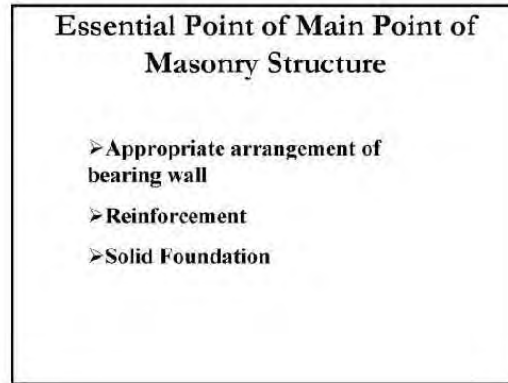
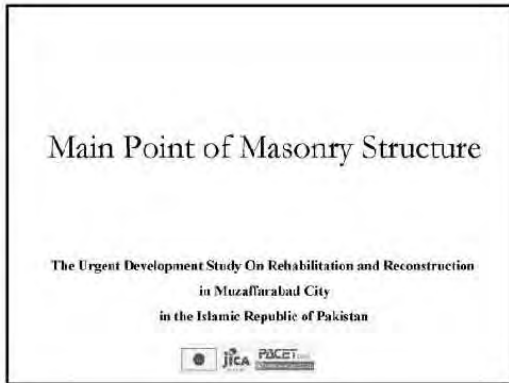
Retrofitting strategy for RC building

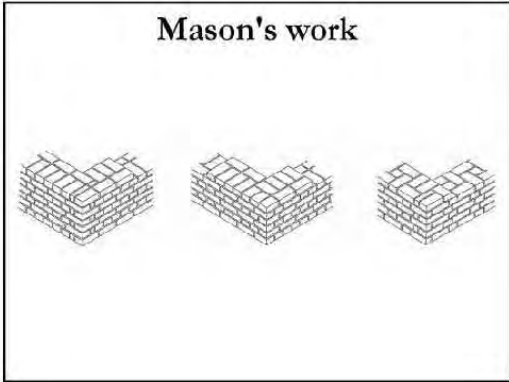
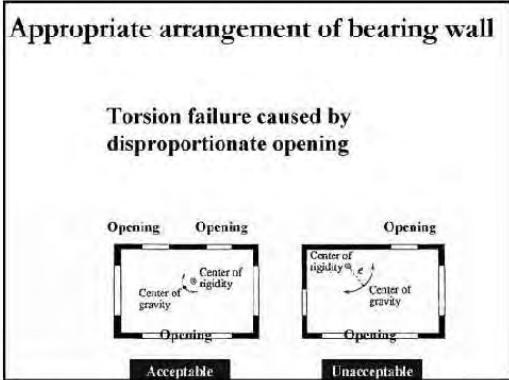
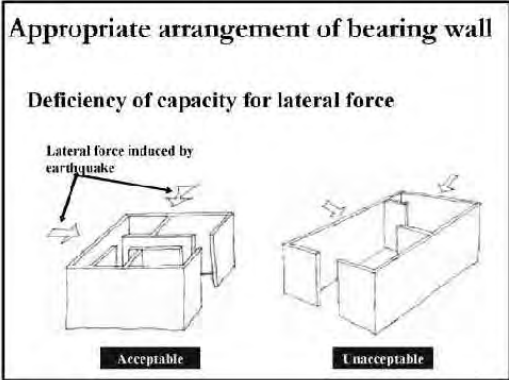
- Continuity of column can be strengthened by some retrofitting method
- Additional shear wall can be effective resist against lateral force
- Capacity of foundation must be increased considering increased mass

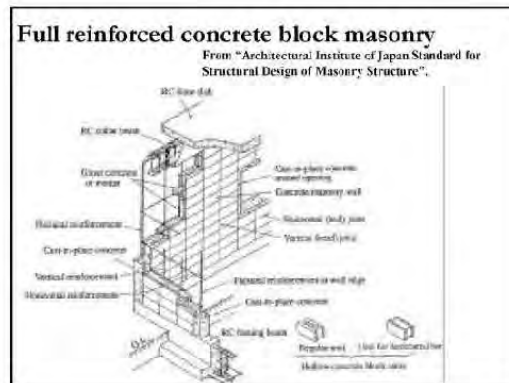
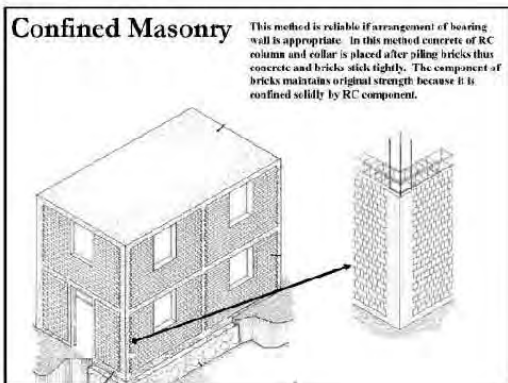
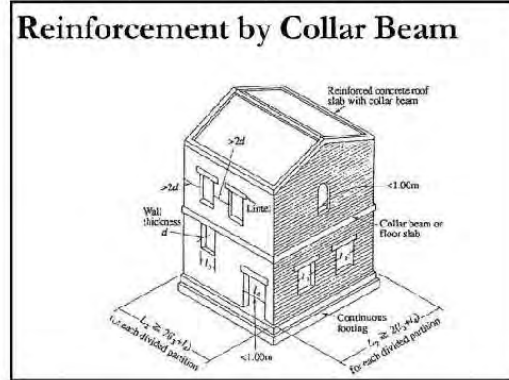
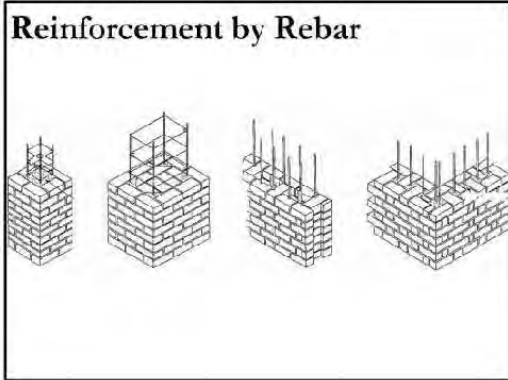


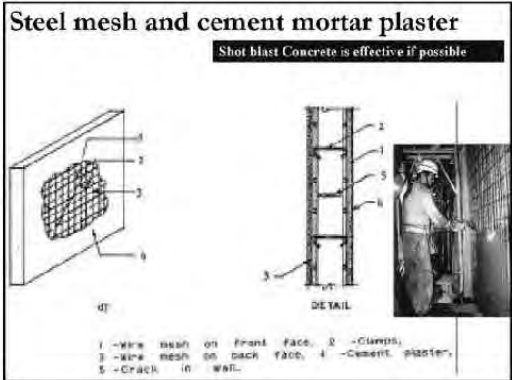
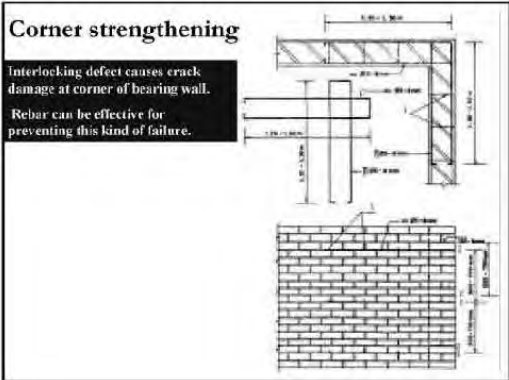
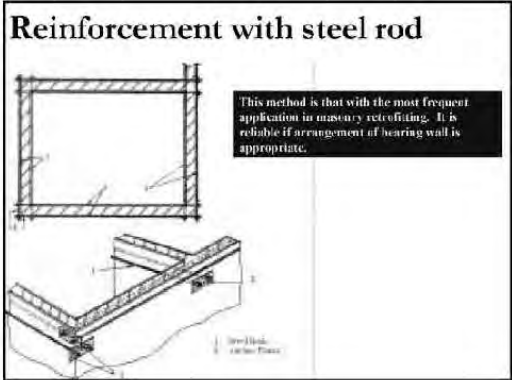
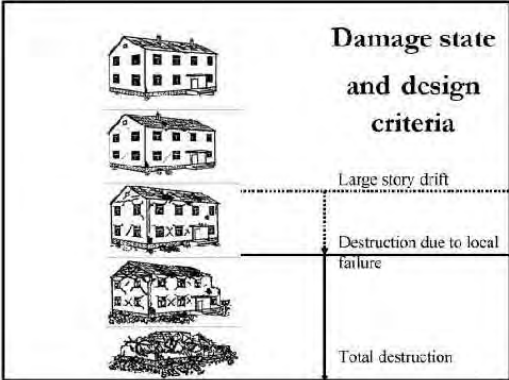


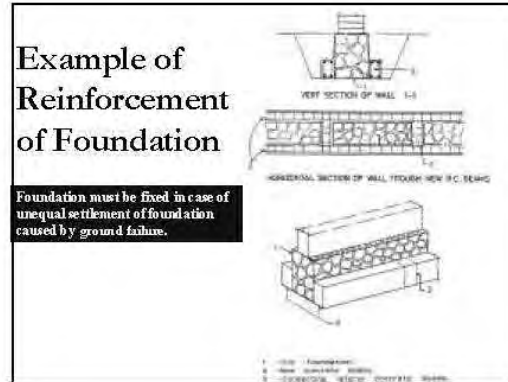
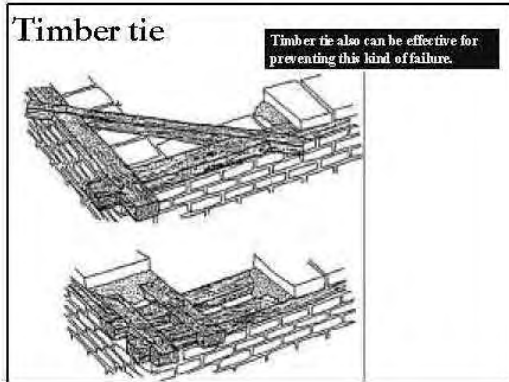
(2) Main Points of Masonry Structure











13.1.6. Terminology

(1) Urgent Rehabilitation

A lot of damaged buildings have stopped being using now in Muzaffarabad city because of the risk of collapse. The residents of those buildings live in tents or shelters. The functions of hospitals, schools, and offices, etc. have stopped. This causes delay of rehabilitation activity after the earthquake. Therefore, many buildings are waiting for judgment of whether it is necessary to repair or to demolish. In this context repair includes retrofitting. The repair and retrofitting need not necessarily reach the level which the latest earthquake-resistant design code demands. However, it is essential to make an effort to be better than the state before being damaged if possible so that the earthquake-resistance may improve even a little because the building is being requested to be used as soon as possible. This is Urgent Rehabilitation.

(2) Long-term Reconstruction

There is a problem of building capacity shortage in this city region which existed before “2005 Kashmir Earthquake”. The buildings where a lot of people are accommodated, such as hospital, schools, and hotels, should apply the structural analysis originally provided, and maintain the level which an earthquake-resistant design code demands using material of an appropriate quality and appropriate workmanship. However capacity shortage exists even for important buildings because there is no official building inspection system in Pakistan where the results of structure analysis and construction state are filed.

There may be some buildings, which need to be demolished and reconstructed because of severe damage. In these case, it is necessary to maintain the level which the seismic criterion demands based on "Long-term disaster prevention target of the city" which should be taken in the future. This is Long-term Reconstruction.

(3) Damaged small-scale shops

On the other hand, there are a lot of damaged small-scale shops built originally in a conventional method without analyzing the structure , and they have already restarted sales. This cannot be realistically prevented because those commercial activities support the region during this rehabilitation period after the earthquake. Moreover, we can do nothing but take “vested rights” into consideration in the buildings which are already operated by user's risk.

When the master plan is applied and the town district is arranged, some blocks will be demolished and the problem will be solved because those buildings will move to a new place. If building similarly in a conventional method at new destination cannot be restricted, then the problem will not be solved.

(4) Countermeasure for damaged buildings

In the urgent rehabilitation phase, damaged buildings are repaired or retrofitted without demolishing an otherwise temporary building where the use period was limited.

Half a year has passed from “2005 Kashmir Earthquake”, and the risk of the aftershock is not urgent now. It is necessary to turn attention to the gradual progress of destruction which was already begun by the earthquake. Ground stability was lost by the earthquake, deformation is still in progress, the supporting capacity of the building foundation is decreasing, and settlement is being generated. The purpose of urgent rehabilitation is taking some countermeasures to solve the above phenomena.

Actually the level, which the latest earthquake-resistant design code demands, need not necessarily be maintained because there is a technical limit in repair and retrofitting. The earthquake-resistance only has to be improved as much as possible by present technology.

(5) Repair

Repair means to return the building to the state before the building was damaged.

(6) Retrofitting (Strengthening)

Retrofitting means to apply some specific construction method to achieve building capacity which is larger than the state before the building was damaged.

(The term of “Strengthening” is also used with similar meaning in this report.)

(7) Demolish and reconstruction

Long-term reconstruction involves demolishing a present building and to building a new permanent building. In that case, it is necessary to maintain the level as the earthquake-resistant design code demands based on "Long-term disaster prevention target of the city". (The earthquake-resistant design codes applied to the whole of Pakistani are ”Building Code of Pakistan” and “1997 UNIFORM BUILDING CODE”, but the revision is working now.)