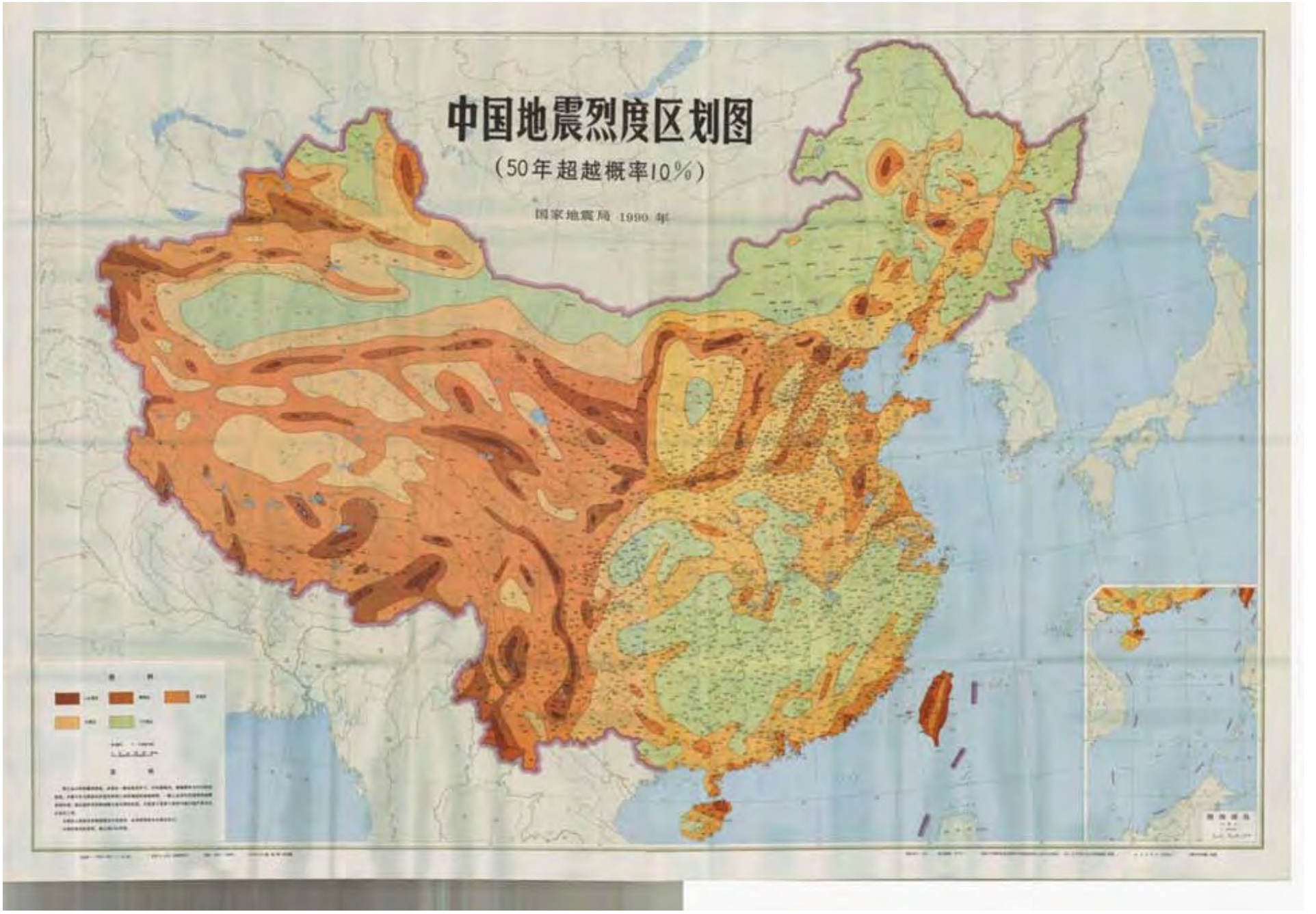
四川大学建筑与环境学院 国际重建 亚洲基金会

安全重建指导手册

SECURITY REBUILD MENU



资料来源：中国国家地震局（1990）
图片来源：http://image.baidu.com/

——Exert ourselves in the struggle for safe and earthquake-resistant houses!

Build Change, incorporated in 2004, is a 501(c) 3 international non-profit social enterprise that designs earthquake-resistant houses and trains builders, homeowners, engineers and government officials in emerging nations to build them. Build Change has ongoing post-earthquake housing reconstruction technical assistance programs in West Sumatra, Indonesia, Sichuan, China, and Haiti; over 70,000 people have benefited from our work. Build Change is a 2008 Tech Awards Laureate and winner of the Katherine M. Swanson Equality Cash Prize for making culturally appropriate, earthquake-resistant housing solutions available to all homeowners, regardless of income level. Build Change's house design for Aceh won a 2006 Excellence in Structural Engineering Award from the Structural Engineers Association of Northern California. Build Change's work has been featured on abcNEWS World News Tonight, National Public Radio All Things Considered, BBC website, and Christian Science Monitor.

On May 12th of 2008, Sichuan, China was rocked by a devastating and deadly 8.0 earthquake. Soon after, Build Change was on the ground in Sichuan; we assessed damages caused by earthquake and developed earthquake resistant design for single story and two story confined masonry houses. Our work in Sichuan includes the following points:

- Build Change has drafted earthquake-resistant layouts and provided hands-on technical assistance to 1344 homes,
- Build Change has trained 404 homeowners, construction workers and engineers on earthquake resistant design,
- In partnership with International Federation of the Red Cross and Red Crescent Societies Build Change has printed 30,000 posters showing best practices for building earthquake-resistant confined masonry homes.

Configuration

Building design in rural China has experienced dramatic changes with the development of economy and culture. From traditional timber house to rammed-earth house and to confined masonry house, rural homeowners have had different housing requirements at different ages.

Confined masonry houses are rather fashionable in the eyes of rural homeowners at current stage compared with timber house and rammed-earth house. Confined masonry structure brings them a sense of superiority, so except for in regions with special housing requirements most rural homeowners would prefer to build confined masonry houses.

People nowadays have higher standards for housing; it is more than a simple shelter for keeping out wind and rain and for storage, it also needs to be safe, comfortable, budget and good-looking.

Good looking: Appearance of a house should be pleasant to eyes; it needs to have a certain shape which makes it different from stiff old houses.

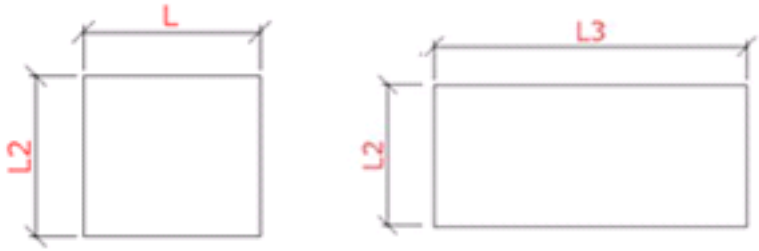
Budget: In rural areas members of an extended family often live together, and they also need room to store grains, farming tools and other supplies; a large house is needed. Layout design should ensure usable floor area as large as possible within homeowner's affordable cost.

Comfortable: Placement of each room should be based on local condition, function, natural lighting, and ventilation, etc.

Safe: Safety is the most basic requirement for house, upon which other qualities are based. The following points should be considered when design layout:

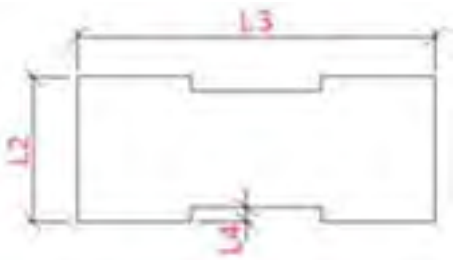
1. Shape of House

1) Square is best for earthquake-resistance. For rectangle house, it is best that length is less than 4 times width.



L3＜4*L2

2) For non-rectangle house plans, it is best if dimension of recessed surfaces is less than 0.15 times of the width of the entire structure. Dimension of recessed surface shall not exceed 0.3 times the width.



L4＜0.15*L2

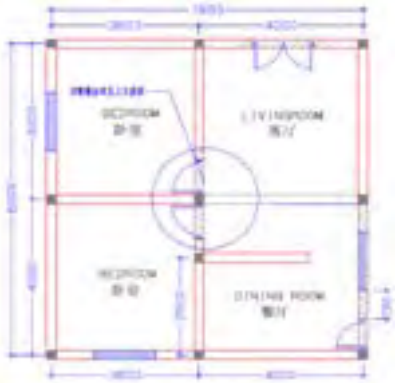
2. Load bearing wall density

1) Bearing wall is a masonry wall that is confined on both ends by tie columns, and without openings. The length of a bearing wall must be:

①If there is opening on wall, length of the wall apart from opening should be greater than 30% of the length of the whole wall

②Greater than 1/4 of the story height

2) Based on experience, to ensure earthquake resistance bearing wall density should be at least 3% in each direction



Wall density= wall section area/ total floor area

Wall section area= length of structural walls* thickness of wall with plaster

Bearing wall density is critical for good performance of confined masonry buildings in earthquakes.

3) For example:

E-W:

L_{E-W}=4+4+2.5=10.5 m

A_{E-W}=10.5×（0.24+0.02）=2.73 ㎡

A=7.6×8=60.8 ㎡

2.73÷60.8≈4.5%＞3%

S-N:

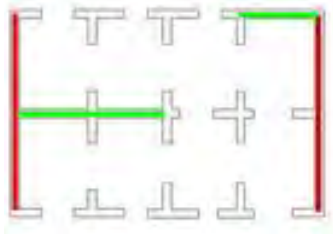
L_{S-N}=3.6×2+4=11.2 m

A_{S-N}=11.2×（0.24+0.02）=2.9㎡

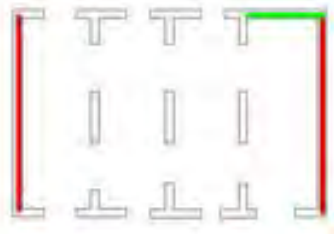
2.9÷60.8≈4.8%＞3%

4) Minimum of two bearing walls in each direction

Good: two bearing walls in each direction

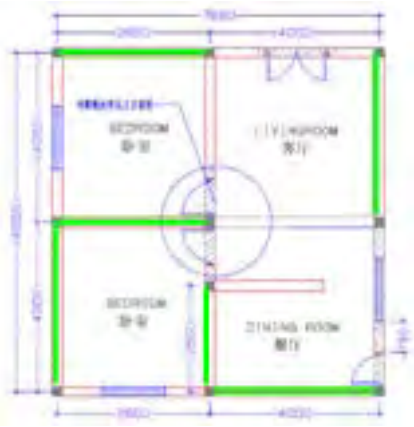


Bad: only one bearing wall in E-W direction



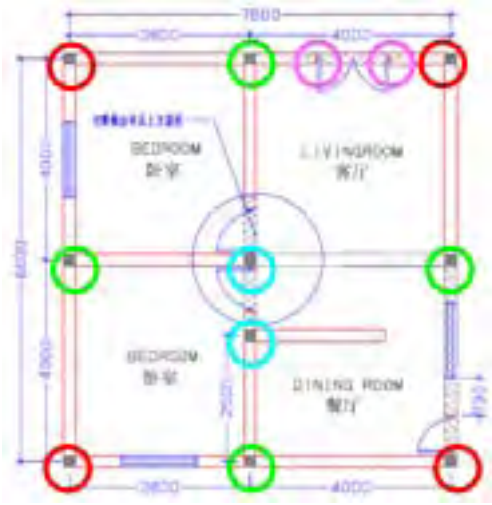
5) Bearing walls should be approximately symmetric in plan.

As is illustrated in green in the following graphic, there are three bearing walls in each direction.



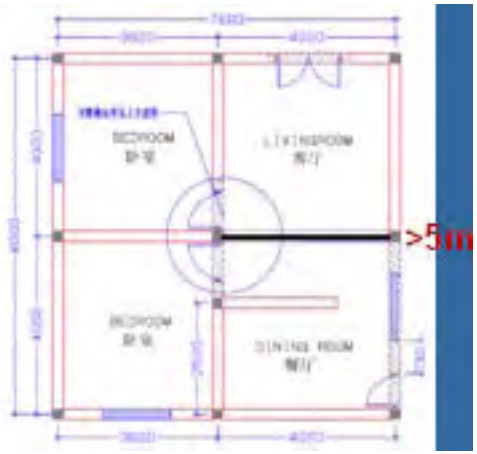
3. Tie column locations for single story building

1) Every exterior corner, as is illustrated in the graphic by the 4 red corners,
2) Every intersection between interior walls,
3) Every intersection between interior and exterior walls,
4) If opening is longer than 1.5m, columns should be set on both sides.



4. Beams

1) If length or width of a wall is longer than 5m, a hung-span beam should be added at the same height as ring beam. A hung-span beam is a beam with two ends resting on columns, and no wall supporting it in between.



2) If precast lintel beams are used, maximum one opening per wall panel. If homeowner insists on making two openings on one wall, lintel beam across the whole wall should be installed.

Material Quality Evaluation

Common fired bricks: Common fired bricks are made of clay, shale and fly-ash, mixed with water, compressed in a mold and fired.

烧结粘土砖

Shale bricks: Shale bricks are made of compressed shale rock powder. They are strong, consistent in dimension and weather resistant.

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Porous shale bricks: Porous shale bricks have holes and are commonly used for partition walls or non-load bearing walls.

多孔页岩砖

Concrete bricks: Concrete bricks may be as strong as common fired bricks, but less porous and absorb less water, resulting in weak bond with the mortar. Concrete bricks are not recommended to build structural walls.

Concrete hollow bricks: Concrete hollow bricks are less strong, and used for partition walls since they function as soundproof and insulating materials. Concrete hollow bricks have poor bonding with mortar, and are not recommended to build bearing wall.

Material testing on site: bricks

Inspect manufacturer’s certificate

Check brick color and determine sintering quality

Measure brick dimension

Test sound

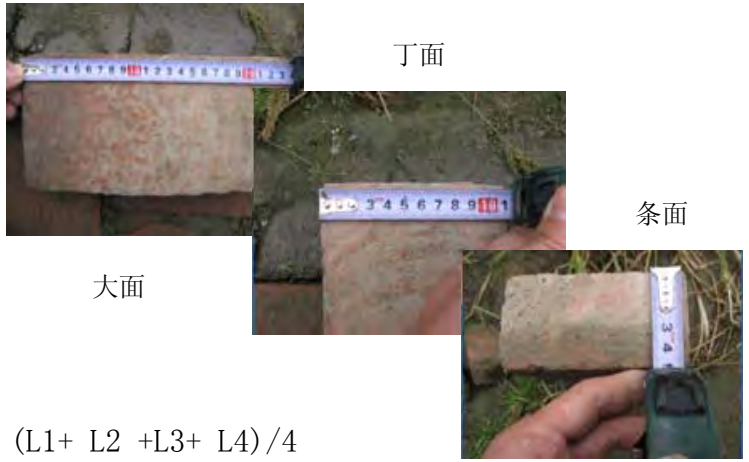
1. Check product certificate and other certificate if possible; attention should be paid to compressive strength and standard size deviation.

2. Bricks of light red, not warped or curved, are better choice. This kind of bricks is also very strong. Dark red bricks are under fired, they are not strong enough. Dark, black bricks are over fired; these bricks are often warped and curved.

Shale bricks

Common fired bricks

3. Take 10 pieces of brick at random and measure dimensions.



L= (L1+ L2 +L3+ L4)/4
Average deviation should be less than 3mm
L1 to L4 are the four sides.

4、Test Sound

The sound of shale bricks shall be metallic clink. If it is not clear, there are probably cracks or impurities inside the brick.

The sound of common fired bricks shall be clear. If you hear a dull thud rather than a metallic clink, there are probably cracks or impurities inside the brick.

Sand

Diameter ranges from 0.16 to 5mm.

According to its formation, there are natural sand and man-made sand.

According to its grading, there are coarse sand, medium sand, and fine sand.

Man-made sand is angular; it has a good bond with cement

Natural sand includes river sand and sea sand. Natural sand is round, has a bad bonding with cement.

Diameter of river sand and man-made sand is approximate. So the best, easiest way to identify them is by touch. If it feels angular and rough it is man-made sand; if smooth, natural river sand. Generally speaking, natural sand has higher mud content, and poorly manufactured sand can have fine particles which will weaken strength in the same way as mud. It is important to test the mud (or fine particles) content of the sand regardless of manufactured or natural sand.

Besides mud, impurities such as mica also weaken the strength of mortar and concrete. Mica content should be less than 2% based on code SDJ207-82.

Mud content field test 1:

Take 5cm sand as sample from pile surface, put into a clean empty bottle. Fill the bottle with clean water, shaking the bottle for half a minute. Then, measure it by eye when sand settles.

If water is dirty, then mud content is high and sand not suitable for use in load bearing part.

Mud content field test 2:

Take some water from the above mentioned bottle and pour on a piece of tissue. When the tissue is dry, compare it with a sample sheet which is easy to carry to the field (sample mud content 0%, 2%, 5%, 7% respectively), and be sure to store the sample sheet in a clean plastic bag.

Mud content field test 3:

Take a handful of sand from inside sand pile. Rub sand 10 times, then gently shake off sand and look at your hand:

2% looks like the color of a light thin film of dust.

5%: color of the film is a little deeper.

7%: color of the film is deep.

Gravels

Diameter of gravels for concrete shall be less than 5cm. There are two types of aggregates for concrete: river stone and crushed gravel.

River stones are round and make a weak bond with cement.

Gravels are angular, and its surface is tough. It makes a strong bond with cement.

Gravel diameter: Gravels with diameter greater than 5cm have weak bond with cement. So recommended maximum gravel diameter is 4cm.

Foundation stones

Cracked, angular stones are the best, but in some areas they not available, so river stones are ok if they are clean and of the right size.

Stones, 30cm~40cm long, at least 150mm thick in the middle, can be used in foundation, embankment, revetment, and etc.

Steel

Steel for reinforced concrete: HRB and CRB

HRB is hot rolled bar. It is rolled and ribbed when hot, more elastic and less rigid than CRB, and suitable for reinforcement of columns and beams.

CRB is hot rolled from a coil, then drawn and ribbed on the surface when it is cold. It is more rigid and less elastic and better for cast in place slab.

CRB diameter is typically within the range of 4mm~12mm. CRB has ribs. There are different types of CRB in terms of strength, for example, CRB550, CRB650, CRB800, and etc.

CRB550 is most widely used. It is commonly used in cast-in-place concrete slabs. Compared with HPB, CRB is more rigid, and tensile stress is also greater.

HRB diameter is typically within the range of 6mm~50mm in diameter. There are different types of HRB, such as HPB235, HRB335, HRB400, andHRB500, and they can be identified by markings on their surface.

Tips to identify HRB and CRB: Check markings that indicate brand and type, and also check steel color and corrosion degree.

Generally speaking, CRB is brighter and silver colored. CRB resists rust a bit more because it is treated with strong acid.

How to check steel on site

Ask for quality inspection report.

Measure diameter with caliper

Read marks on steel, and then check if it matches quality inspection report.

1. What needs special attention when checking quality inspection report?

First, ask the vendor to show quality inspection report. Check manufacturing goods No. and manufacture date, at top right. The more recent the date, the better.

Original report is better. If it is copy, remember to check manufacturer's red seal at bottom right.

2. How to check marks on steel matching quality inspection report?

3/xx/xx/14
2/xxx/10
xx/4/12
.....

Numbers refer to steel grade and its diameter. Letters are the abbreviation of the manufacturer.

For example: XG/3/14
XG= steel manufacturer
/HRB335/diameter14

3. How to measure diameter?

Observing rib size, measure the minimum nominal diameter (between ribs).

Fix caliper on the part of minimum nominal diameter, read caliper.

Do not use rusty or recycled steel!

Heavy rust decreases the bonding of concrete and steel, and rust will spread through reinforcing steel inside concrete like cancer.

Cement

Cement is a bonding material. After mixing with water, it changes from paste to strong solid. Cement's function in concrete and mortar is to bond sand and gravel together.

Cement has many varieties like Portland cement, Portland slag cement, Fly-ash cement, and so on. Each type of cement functions differently.

Portland cement is the most common and can be used under almost any condition.

Portland slag cement is used for damp proofing course of roof or bathroom, etc.

Fly-ash cement is used in large projects and large concrete pours.

How to check cement on site?

1. Check bag appearance, manufacture date and product No.

2. Ask for quality inspection report and check if it matches product or not.

3. Check if it is damp or not. Open cement bag, examine color, and touch cement. It should be dry and powdery, no hard lumps.

Cement color test:

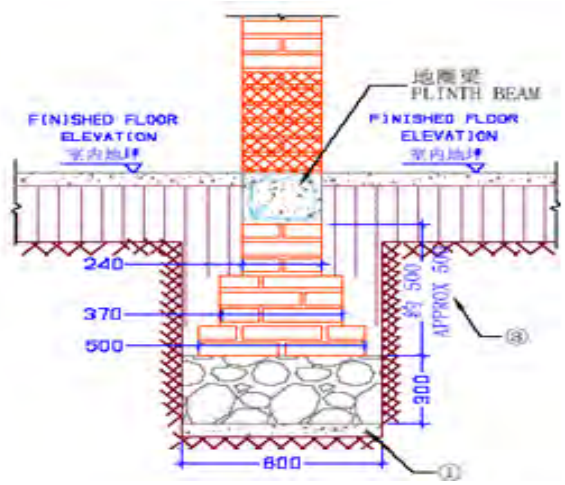
Color is key to identify cement quality in the field. Although it is subtle, notice the color of the cement sample on the right is more yellowish.

If there is any doubt on additive content, check manufacture certificate carefully and consult local construction bureau.

Confined masonry structure quality inspection

Construction sequence of confined masonry structure: ground work- foundation- plinth beam- masonry wall- tie column- ring beam- floor slab/ roof slab

1. Foundatio



1) Foundation pit should reach firm ground (regarding one or two story residential houses).

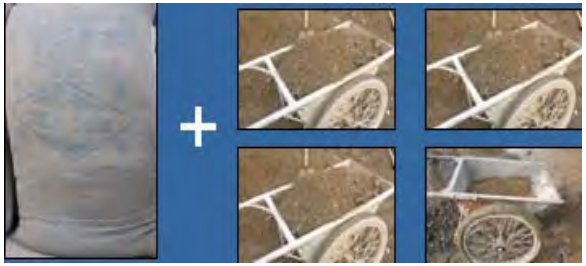
2) Foundation pit should be deep enough so as to be against overturning (usually minimum depth 80cm).

3) Column toothings should be made to safe guard connection between brick masonry footing and tie columns.

4) Cement mortar M5 for brick masonry footing

Weight ratio: M5 cement mortar=50kgcement +3.5wheelbarrow sand

Volume ratio: M5 cement mortar=50kgcement +370kg sand



2. How to deal with unusual conditions at ground base?

Attention should be paid to unusual conditions at foundation base, such as septic tanks, old wells, etc. Improper treatment will easily lead to different settlement.

Common practice is to backfill holes with small gravels, clean soil, cement mixed with soil, and so on. Compact layer by layer. If the hole is deep and wide, simply to backfill the hole is not recommended. Homeowners, however, shall ask an engineer to come to the site and follow engineer's suggestions or solutions.

3. Stone masonry footing

Lay 10cm thick C10 concrete as base layer. Place all stones flat, layer by layer.

Clean and remove dregs

4. Mix proportion of C10 concrete for stone masonry footing
C10=1bag cement (50kg) +1.5 wheelbarrow sand +2.5 wheelbarrow gravel

5. Stone placement

Make sure gaps between stones. Do not lay bricks too close or overlapping.

Fill gap between stones completely with concrete, or the gap will be potential safety

6. Concrete pouring of stone masonry footing

Use vibrator to vibrate concrete, but do not vibrate too much, and screed surface of stone masonry footing.

7. Concrete curing

Cover concrete with straw, cement bags, plastic bags, or plastic films.

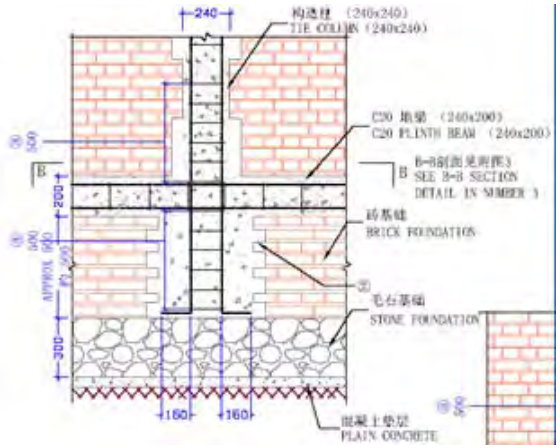
Water it once a day in winter, 3 times a day in summer. Make sure concrete surface is moist.

8. Width of brick masonry footing

50cm: 2 layers of bricks
37cm: 3 layers of bricks
24cm: 3 or above layers of bricks

Plinth beam

1. Plinth beam



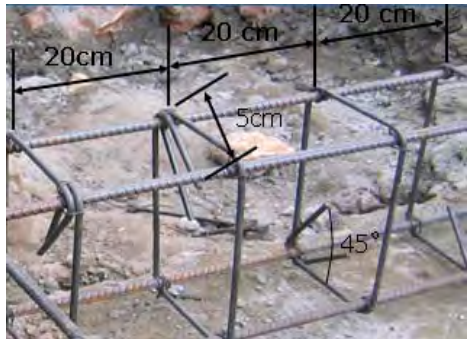
2、Concrete≥C20

C20=2 bag cement (each 50kg) +1.5 wheelbarrow sand+3.5 wheelbarrow gravel

3. Long bars≥4Φ12

Long bars: 4 HRB335, diameter 12mm

Stirrups: HPB235, diameter 5mm, spaced at 200mm



4. Bar splice of beam to beam

1) Anchors should bend inward at 90o.
2) Anchor length should be at least 36cm.

5. Plinth beam bars binding

1) Bind stirrups and long bars, long bars at each intersection firmly with steel wire.
2) Stagger stirrup hooks so as to improve confinement of concrete, especially at top and bottom of tie columns and at the ends of bond beams.

6. Plinth beam formworks

1) Beam height: 20cm
2) The width of top and bottom of formwork shall be the same
3) Use spacer to separate formworks and steel bar to ensure concrete cover at least 20mm thick.

7. Formworks removal

1) Remove formworks 24 hours after concrete pouring. Extend removal time in rainy days.
2) Quality inspection after removal:
   * surface level and with edges and corners or not
   * with cracks or not
   * with cells or holes or not

* with exposed bars or not

3) Cure concrete for 3 days after formwork removal.

Concrete Mixing

There are two ways to mix concrete. One is to use a machine and the other is by manual labor.

If using a mixing machine: Input order: a small amount of water- sand - cement - gravel - water.

Stirring time: 90-120 seconds

The manual labor portion is followed in the following sequence:

First, the ground should be cleared of garbage and dirt; and of course mixing on a paved surface is preferred.

Second, attention should be paid to the following input order:

Step #1: Mix sand, gravel and cement until the color is uniform

Step #2: Dig a hole in the middle to pour water into; then mix。

Step #3: The amount of the water should be proper. Mixed concert should be used within 90 minutes.

Concrete Pouring

* Use a vibrator to vibrate concrete so as to improve concrete strength and durability. Insert vibrator quickly but pull out slowly. Space between insertion points shall be 30-40cm. Stop vibrating when floating slurry appears on the surface or surface no longer sinks.

* When pouring over 2m-high vertical structure, 10cm thick block pulp should be done first. Concrete puree or 1:2 (volume ratio) of cement mortar shall be used.

* Concrete slab shall be covered with plastic film after pouring to prevent cracks.

Formworks removal

* For vertical structure, such as columns, usually formworks can be removed in 24 hours after pouring when concrete component has reached certain strength and edges and corners won't easily fall off when touched upon.

* For horizontal structure, such as beam, bottom formworks removal is usually completed 14 to 20 days after concrete being poured. (If condition permits, strength of concrete specimen cured under the same condition should be tested; when strength reaches 70% formworks can be removed)

* In addition, formworks removal is also affected by weather and additives. In summer with high temperature and long-time sunlight, concrete components gain strength quickly, while in winter concrete strength increases in a slow rate due to low temperature and short-time sunlight, so formworks removal time should be extended.

Concrete curing

* Curing is very important for the strength of concrete structures.

* Initial setting time: from the moment when watering cement to the time when the slurry begins to become solid. Final setting time: from the moment the slurry begins to become solid until the time it has fully solidified. For cement produced in China, the general initial setting time is 1 ~ 3h, final setting time is 5 ~ 8h.

* Concrete strength at early stage is very important for the ultimate strength. Curing should be done in 12 hours after pouring.

* Slab curing: spray water over slab and cure for 1 day in the beginning; and then spray more water and curing. This can prevent scaling.

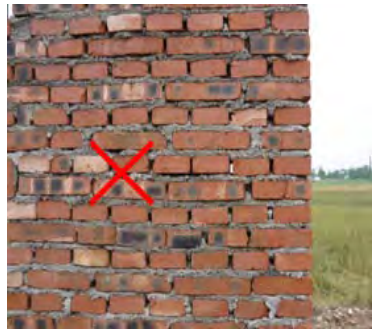
* Cure concrete for 7 consecutive days till the concrete surface is moist. In winter concrete curing time will need to be extended.

Brickwork

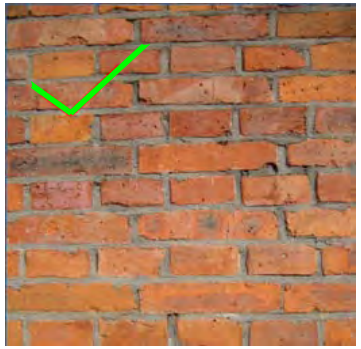
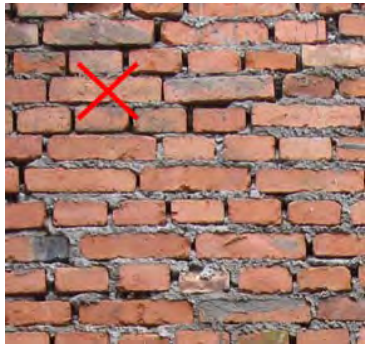
For confined masonry structure, walls bear load. If walls are of poor quality, structure safety will be at risk.

1. Water bricks before construction. Dry bricks are not allowed, because they will absorb water in the mortar and weaken bond between bricks and mortar.


2. Bed joints are straight, and head joint are vertical. Two experienced workers build the wall from two sides to the middle. Stretch white line while building wall to check the height, and use plum bob to ensure wall vertical.

3. Head joint is full (≥80%)

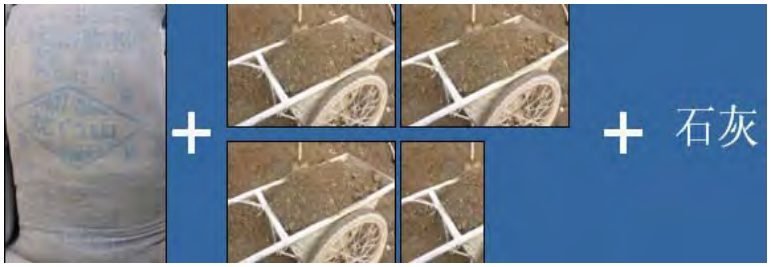



4. Bed joint is full (≥90%).


5. Use cement mortar M5 or composite mortar for structure above plinth beam

Composite mortar M5 =50kg cement+3.5 wheelbarrow sand+25kg lime

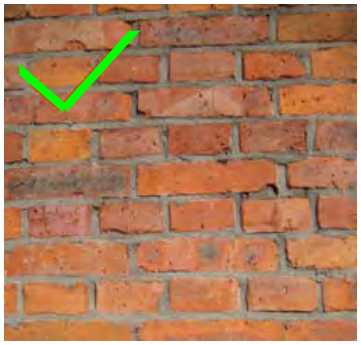
Composite mortar M5=50kg cement+380kg sand+25kg lime

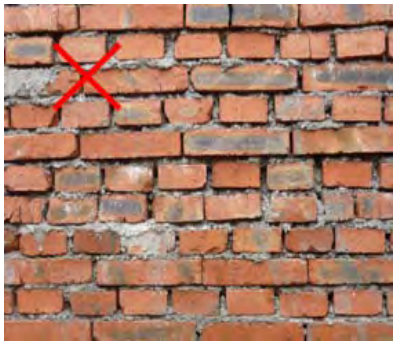


1) Use mortar within 2 hours of mixing, or mortar will harden and go against wall's strength.
2) Composite mortar is recommended for wall. Adding lime into mortar will help increase mortar workability and masonry compaction.

6. Brickwork

1) Use MU10 bricks.
2) Use English bond. Straight joint is not allowed.
3) Do not use broken bricks. If so, make sure joints full filled with mortar.





7. Plastering

1) Plastering can help increase wall strength and earthquake-resistance.
2) Use at least mortar M5 for plastering.

8. Wall

All walls shall be 240mm thick; in degree 6 (seismic fortification intensity) area, thickness can be 180mm.

Every wall bears load, so shall be 240mm thick.

Wall between openings ≤1000mm (length) shall have strengthening measures.

If homeowners insist on having door and window on the same panel, it is recommended to build cast-in-place lintel beam to go across the whole wall and tie its reinforcements into tie columns on both sides. Lintel beam shall be poured together with tie columns.

Tie Columns and Toothing

1) Maximum 300mm for a tooth,
2) Width of tooth: 60mm
3) Protruding tooth shall be symmetrical.

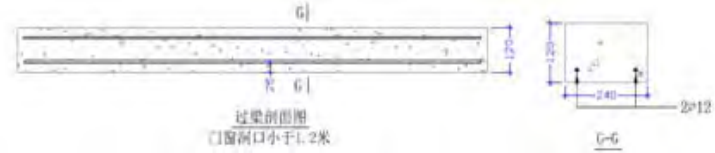
Horizontal reinforcement ≥2Φ6@500, extension into wall at lease 1m

1) Vertical spacing is 50cm, about every 7 to 8 courses of brick put 2 horizontal reinforcements.
2) Extend into wall 1m, with hook of 90 ° at two ends.

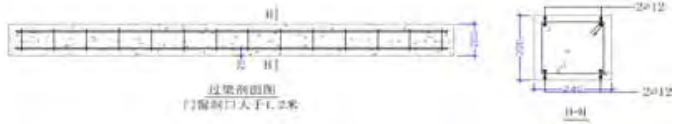
Lintel beam shall extend into wall 24cm.

Either precast or cast-in-place lintel beam shall be extended into wall 24cm.

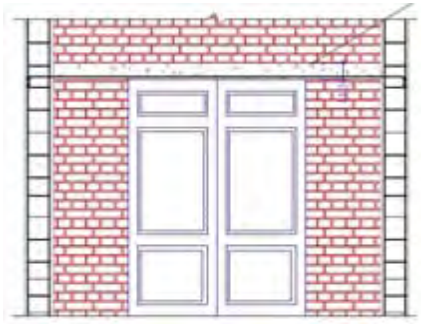
When opening <1.2m, lintel beam height shall >120mm, 2 Φ 12 as reinforcements.



When opening > 1.2m, lintel beam height shall >240mm, 4 Φ 12 as reinforcements, Φ 6@200 as stirrups.



Openings shall be no more than 1.5m. Large openings will weaken wall's load bearing capacity and go against house's earthquake resistance.

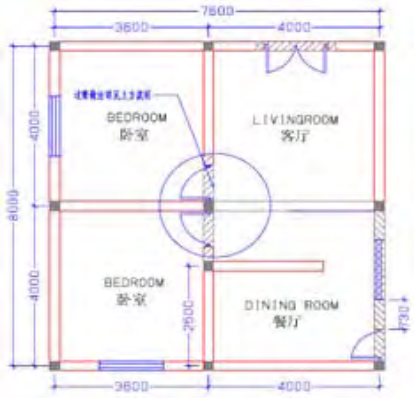


When opening > 1.5m,

1) Confine the opening with tie columns at both sides,
2) Cast-in-place lintel beam go across the whole wall.

Tie Columns

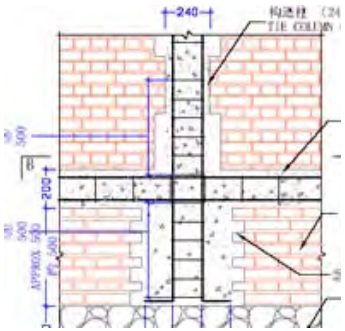
1) Tie columns should be installed,
2) Locations of tie columns should reach standards,
3) Add tie columns if longitudinal wall spans over 4.2m.



Tie column concrete ≥ C20

C20=2 bag cement (50kg) +1.5 wheelbarrow sand+3.5 wheelbarrow gravel

Longitudinal bar ≥4 Φ 12
Stirrups at shear zone≥ Φ 6@100

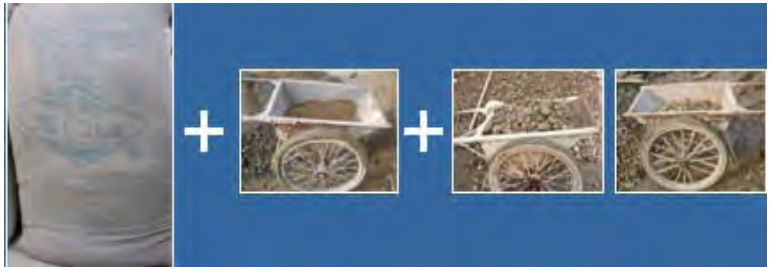


1) The embedded part of columns into foundation shall have shear zone;
2) Stirrups shear zone 500mm long;
3) Bar splices of long bars are not allowed at shear zone, and stagger splices.

Anchorage length of bars into ring beam ≥360mm

Ring beam 2：concrete ≥C25

C25=1 bag cement+ half wheelbarrow sand+ 1.5 wheelbarrow gravel



Concrete slab

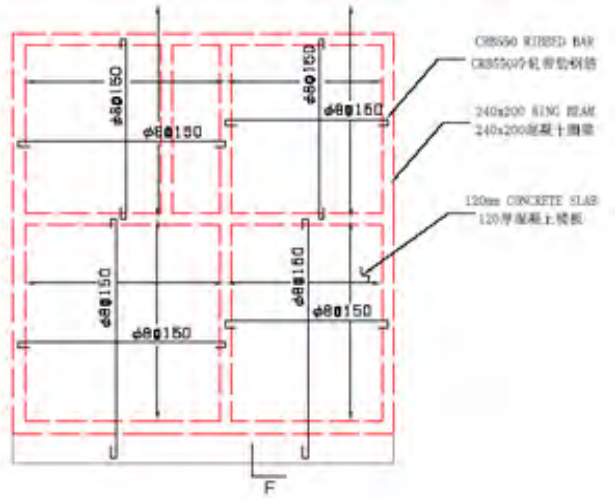
Advantages: good earthquake resistance; roof slab can be used for other purposes; long life span

Disadvantages: difficult to construct; tending to have quality problems; likely to crack

Warning: Don’t build roof or floor using precast concrete planks.

The thickness of concrete slab shall be≥ 120mm and reinforcement should be placed in both directions.

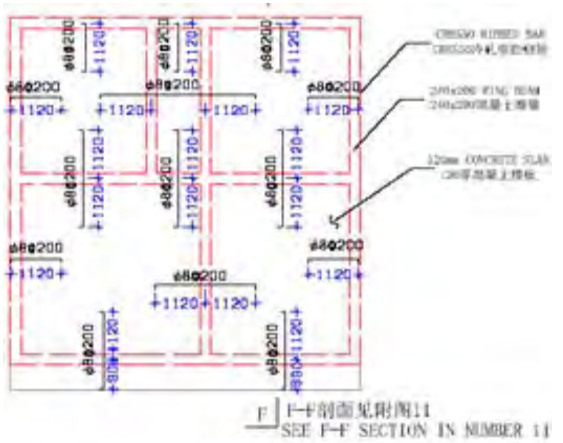
Bottom reinforcement ≥Φ10@150.



屋面板板底正筋配筋平面图

Top reinforcement ≥Φ8@200

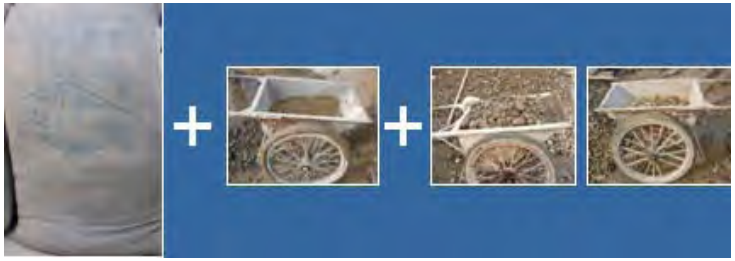
Top reinforcement extension shall be 1/3 of the house’s length in the same direction.



屋面板支座负筋配筋平面图

Concrete for slab ≥C25

C25=1bag cement + 0.5 wheelbarrow sand +1.5 wheelbarrow gravel



Parapet wall

Extend tie column bars 50cm above roof to confine and strengthen parapet wall.

Tile roofing

Advantage: light; efficient drainage; warm in winter and cool in summer; easy to construct.

Disadvantages: Wood tends to rotten easily, Clay tiles need changing after several years, Construction takes a long time.

Gable wall

Masonry gable wall has a big potential safety risk.

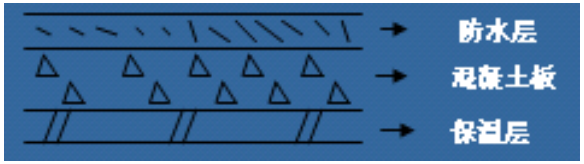
Use wood, bamboo, or other light-weight materials to build gable wall.

Place roof beam to confine masonry gable wall.

Waterproof Materials and Construction

Waterproofing of concrete roof slab is very important. Several different approaches have been used in the past, each with advantages and disadvantages.

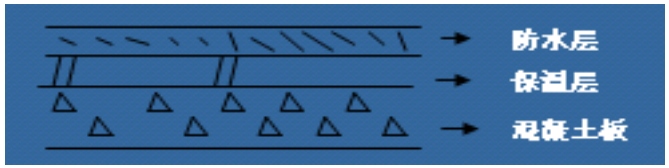
1. Insulation layer (bottom), concrete slab (middle), waterproof (top)



Advantages: Efficient in heat insulation.

Disadvantages: It is liable to crack due to concrete creep and expansion and contraction caused by heat and cold.

2. Concrete slab (bottom), insulation layer (middle), waterproof (top)



As concrete is brittle, insulation layer is moved to the middle.

Advantages: As insulation layer is in the middle, waterproof is hardly influenced by concrete creep.

Disadvantages: Waterproof is easily affected by environment, resulting in poor durability.

3. Concrete slab (bottom), waterproof (middle), insulation layer (top)

Nowadays environmental factors and brittleness are taken into consideration in waterproofing. Thus, we recommend this approach.

Advantage: not liable to aging and damages.

Disadvantage: increasing load bearing and more expensive

According to the physical properties of waterproofing materials, we divide them into ductile materials and brittle materials in general terms. Brittle materials are those that crack easily, like glass, bricks, and concrete. Ductile materials are those that are flexible and can bend without breaking or cracking, like plastic, wood, and steel.

Brittle materials: use cement, sand and gravel as raw materials, or add small amount of additives, high polymer into it to control or decrease porosity and increase interface

solidity, to make a kind of cement mortar with certain anti-permeability.

Ductile materials: it refers to waterproof sheet in narrow sense. Ductile waterproof materials have the properties of good tensile strength and extension, light weight, convenient for construction. But it requires good workmanship. In terms of puncture resistance and age resistance, brittle materials are better than ductile materials.

1. Asphalt (modified SBS)

Asphalt has a long history. It is first found in use as waterproofing material on the linen of Egyptian mummy.

As asphalt is put in use in construction, people find it tend to crack in large temperature difference and under dynamic load. With the development of applied chemistry, people began to add sulfur additives into asphalt to increase its ductility, but soon it was found that asphalt was oxidized by ozone.

Nowadays, asphalt is a mixture of polyisoprene, sulphurised isobutylene, disulfied rubber, etc.

SBS, modified asphalt
Property: ductile
Advantage: SBS with coat are not easy to crack.
Disadvantage: Poor corrosion resistance and durability

The key to use SBS as waterproofing materials by means of hot adhesion method is to control the speed of blast burner movement; if the burner moves too fast, SBS cannot adhere to concrete slab firmly; and too slowly, SBS will be burned.

2. Modified cement

Property: brittle while with ductile quality

Advantage: not easy to crack and good bonding with cement mortar

Disadvantage: Price is a bit high.

Modified cement is a kind of cement mortar added with some additives to change its chemical property. A layer of dense crystals will appear on surface as a result. Crystal penetration into concrete is 5mm -15mm deep, functioning as waterproof.

3. Silicate, inorganic salts, and high aliphatic acid additives

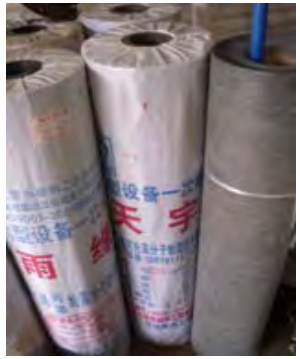
Property: brittle

Advantage: easy to construct and cheap.

Disadvantages: very brittle, easy to crack under minor dynamic load.

Add silicate additives (powder or liquid) while mixing concrete or while pouring screed coat on concrete slab. Silicate additives will fill gaps inside concrete and make it function as waterproof.

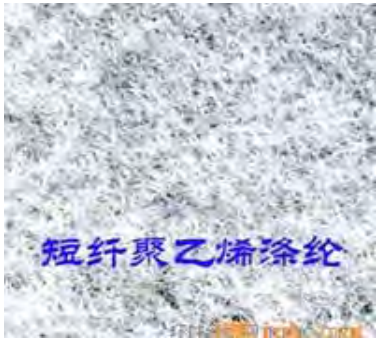
4. Non-woven fabric waterproofing sheet and SBC



Advantage: cheap; its price is 1/6 of SBS's.

Disadvantage: poor in fungus resistance, waterproofing, and durability. Asphalt in fabric is usually from waste rubber.

Non-woven fabric has a short service life. It is easily to be sliced and peeled off. Non-woven fabric is low-end product of waterproofing materials.



SBC also called polyethylene fiber is a new type of composite waterproofing. It is widely used by way of cold adhesion. It has better performance than asphalt in aging resistance and waterproofing.

5. Polymer composites—synthetic resin and rubber

Property: brittle and ductile

Advantages: A layer of film forms in the process of agglutination, and this film has good stability, aging resistance, waterproofing, and other physical properties.

Waterproofing Conclusion

Waterproofing paints and additives

Cement base materials will penetrate and form dense crystals which function as waterproofing. These crystals are different from silicate additive's film on the surface, and easy to be reconstructed.

Silicates are brittle. They tend to crack in big temperature differences and small displacements. But it is easily constructed and thus widely in use.

High polymer, or PU, is a new emerging waterproofing material. It behaves not as good as modified cement in reconstruction, but has a good performance in durability and anti-corrosion. So there is still room for its development.

Waterproofing sheet

In terms of waterproofing and durability, SBS is much better than non-woven fabric. However, SBS asks attention to details and requires good workmanship.

Contractor Qualification

Framework

General arrangement of construction law from national to local authority: construction law > construction rules and regulations > rules and regulations issued by construction department > local building codes > local construction rules.

Theory

Construction law: construction laws are the core of construction legal system. They are issued by National People's Congress, so are fundamental and mandatory, such as Construction Law of the People's Republic of China.

Construction rules and regulations by state council: construction rules and regulations are issued or approved by State Council. People also call them regulations, rules, or measures. For example, Regulations on Administration of Surveying and Designing of Construction Projects.

Rules and regulations issued by construction department: they are supplementary specifications to law and rules and regulations. They are jointly released by construction department and State Council, so they have force in specific field. For example, Regulations of Civil Construction Energy Efficiency.

Local Building Codes: These codes are released by People's Congress and its Standing Committee of provinces and municipalities directly under the central government, or autonomous regions. For example, Regulations of Shanghai Municipality on the Administration of Construction Market.

Local construction rules: these rules are released by local people's government. They are applied by local construction bureau.

Contractor Qualification

The 2nd chapter of Construction Law of P.R. China specifies requirements for construction permit and professional qualifications.

Construction permit: construction department in charge of a specific area will issue construction building permits to contractors who meet requirements.

Professional qualifications: it includes construction company's registration and professional's qualification including inspection officer's, engineer's and designer's qualification. Usually construction company qualification certificates expire in 5 years.

Contractor qualification: it includes construction permit, certificate and registration, safety license, business license, and so on.

Engineer qualification: it refers to engineer license and intermediate title. The former is acquired after passing nation-wide test, the latter is assessed and given by relevant institutions.

Contract and certifying documents issued by local government

Contractors often do not put all their documents on site (as required). Therefore it is best to start by visiting the Township Construction Office to intensively check contractors' qualifications before construction. Then make a random inspection on site to make sure personnel actually doing the construction are affiliated with the registered documents (license and professional qualification).

1. Below are examples of contractor qualification documents.

2. Safety license

The State Council mandates all construction enterprises must renew their safety license and be assessed every three years.

3. Contractor certificate

Contractor certificate and legal representative letter should be checked.

4. Business license

Make sure it matches other documents and is not expired.

5. Building permit

Building permit is the certificate issued by relevant government department when a contractor meets government's requirements for construction qualifications.

6. Below are examples of engineer qualification documents.

7. Engineer's license

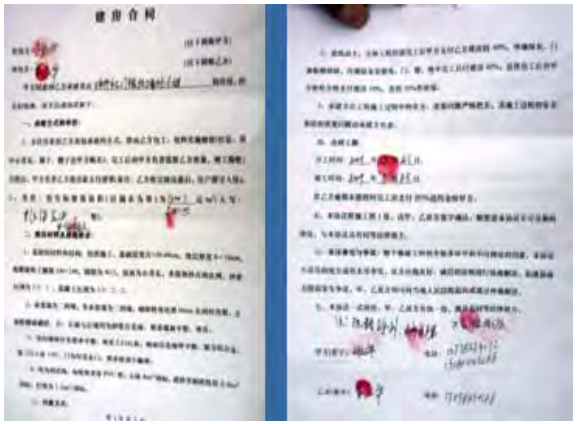
The best qualification is national engineer's license which is issued by the national or provincial government after passing engineer's examination.

8. Check engineer’s license online

9. Intermediate certificate

If a contractor does not have engineer license, intermediate certificate entitled by construction institution is also acceptable.

10. Contract



11. How to deal with someone with no credentials?

In rural areas, many builders do not have all of the required certificates and licenses. Sometimes, a relation will help build a home for a family member, or a farmer will build his own house without hiring a contractor. In these cases, the most important thing is to ensure safety of building.

If there is a problem with the safety of the construction:

1) Document the problem clearly and completely by photographs, checklists and record relevant data.

2) Talk with builders and homeowners about problems and propose solutions. Check contract between builder and homeowner for relevant details and encourage homeowner to demand contractor to fix the problems.

3) Communicate these concerns to local government and provide them with copies of all observations (checklists, photos of good or bad practices) so they can make decisions on what to do.

Contract

Contracts are prepared based on construction laws and local conditions. They are meant to protect the rights of both contractors and homeowners. Contracts are not a mere formality; they help prevent problems due to misunderstandings. Construction is so complicated, with so many small but important details that it is important to have both parties reach agreement in writing before starting work.

Why do I need a contract?

1) A contract assures rights and interests of both parties;
2) A valid basis for resolving disputes;
3) Guarantee construction quality and construction period;
4) Guarantee project cost and payment terms.

How to defend legal rights?

1) Keep all important materials and evidence, such as contract, photos etc.;
2) Seek mediation from village or neighborhood committee;
3) Resort to court.

Main contents of a contract:

1) Parties of the contract;
2) Construction details, quality requirements and construction period;
3) Contract style and price;
4) Mutual rights and obligations of both parties;
5) Terms of payment;
6) Measures for resolving disputes;
7) Guarantee or warranty on construction quality;
8) Others.

Common problems from incomplete or no contract:

1) Design/ layout: some homeowners refuse to pay balance because design is not what they want, or they think materials are of poor quality, or they hold different opinions on construction details. This problem can be prevented by attaching construction drawings to the contract.

2) Scope of work: does the payment include all aspects of the construction? For example, does the payment cover the cost of waterproofing roof slab? Waterproofing is an important step in protecting the slab and if not detailed in contract, it may not be completed and the safety of the house will be compromised after a few years.

These are valid reasons to be dissatisfied but without a contract it is not clear who is at fault. Many farmers do not understand the contents of a contract and are not very good at negotiating with contractors. Often homeowners will sign what construction team wants, which usually is against their interests.

Reasons to sign a contract in rural construction:

1) To clarify responsibilities of both parties including scope of work of contractor and terms of payment by homeowner. For example is the homeowner responsible for providing materials? Who will examine material qualities?

2) To clarify design and construction details. Attach clear layouts and construction drawings to contract. Drawings are required when applying for the building permit and they are also useful when calculating payment.

3) To specify how to deal with unexpected situations. Contract should detail who will be responsible for cleaning debris in the soil, or who will pay for fixing damages caused by natural disasters such as flood, earthquake etc. within construction period.

4) Contract provides an impartial platform for resolving disputes. Contractors do not always follow contract exactly, but without any contract it is much more difficult to hold a contractor accountable for mistakes. Negotiation, and problem solving start by examining the contract.

Contract requirements: legal requirements

1) License and registration numbers of construction team and building permit.

2) Sign contract with seal and each page with fingerprint. A formal contract is supposed to have signature of representative of a construction company and legitimate seal.

Contract requirements: contract style and price calculation

Define what is included in unit price:

1) construction labor and materials

2) construction labor but no materials; owner is responsible for materials

3) scope of work (including furnishing,Waterproofing.)

Define Calculation of total price for payment:

1) by total area of outer wall (Square meters)

2) by volume (Cubic meters)

Contract requirements: construction drawings

1. Layout

1) shows house structure and plan of rooms

2) Homeowner can design and provide or;

3) Contractor can design and provide layout

2. Detailed Construction Drawings

1) Provided by contractor

2) show important details including connections of steel reinforcements, thickness of walls, width of foundation and type of lintel used on openings

3) must meet construction requirements of local code

Contract requirements: terms of payment

Advance payment: after signing contract with seal; limited to 5% to 10% of total budget.

1st payment: after casting plinth beam, removing formworks and quality inspection of foundation and the beam.

2nd payment: after completing masonry walls and installation of column steel reinforcement.

3rd payment: after casting ring beam and cast in place slab roof.

4th payment: at the completion of house, and no problems are detected.

Maintenance deposit: this is commonly held by local construction committee, about 5% of the total construction budget, and paid to contractor after half a year or one year. If there are any quality problems, homeowner can require construction team to fix them, or homeowner can fix himself and recuperate the cost from the deposit.

Contract requirements: responsibility of construction quality and site safety

1) Site safety: Contractor is responsible for the safety of construction site and of builders. Security measures should be taken and warning signs be posted.

2) Materials quality:

If contract covers both labor and materials, homeowner has the right to reject low-quality materials provided by the contractor. This should be noted in the contract to protect the homeowner's rights.

If contract stipulates that the homeowner will provide materials, then contractor has the right to refuse low-quality materials and demand materials of good quality.

3) Construction problems

If a problem can be fixed, then fix it; if cannot, the part concerned should be torn down and rebuilt.

Contract requirements: others

1) Define method to resolve problems when either party does not follow the terms of the contract

2) Define punitive measures to punish and discourage non-compliance

3) Defines who is responsible for negotiating problems and which local government body will settle problems and assess disputed quality problems.