

# Cause Analysis and Control Measures of Cracks in Filling Wall of Reinforced Concrete Structure

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The crack problem of the filler wall in reinforced concrete structure appears more and more frequently with its wide application. This paper analyzes the causes of the cracks in the block filler wall in the frame of the reinforced concrete structure from the aspects of external environmental factors and intrinsic material factors, and puts forward the corresponding prevention and control measures. The control measures can improve the safety, comfort and quality of housing construction to avoid the trouble to the daily life of the residents because of cracks.

## 1. Introduction

Filler wall in reinforced concrete structure, with strong integrity, strong corrosion resistance, strong durability, convenient design and construction, can be used to larger and more flexible space partition room in column bearing system, and has been applied more widely in the field of construction. But there is a common quality of engineering defects - cracks. Cracks have a number of negative effects on the building. For example, it will cause the heat bridge effect even weaken the wall insulation and thermal insulation properties. The existence of cracks reduces the durability, applicability, bearing capacity and seismic performance of buildings. Also, it can greatly reduce the beauty of the building appearance. When the cracks are serious to a certain extent, it will affect the structural safety of buildings and affect people's normal life (Khankhaje et al., 2017).

## 2. Definition of related concepts

### 2.1 Meaning of reinforced concrete structure

The reinforced concrete structure is made of concrete reinforced with steel-reinforced bars, which are formed by linear rods such as beams and columns to support the horizontal and vertical loads and are divided into small spaces by filling walls to meet the functional requirements.

### 2.2 Meaning of filler wall

The filler wall is the most basic building element in the building structure and the solid structure between the frame and the column. In the field of architecture, most of the filling wall plays the role of cutting off, connecting and enveloping space. The entity frame is the main component of the building unit, it can be I-beam, column and so on. The filler wall is divided into load-bearing wall and non-load bearing wall according to the stress form. The filler wall in this paper is mainly self-bearing wall.

### 2.3 Basic theory of crack

#### 2.3.1. Meaning of crack

Cracks are the presence of faults or breakage of building materials. In the field of architecture, the wall crack is mainly caused by the internal stress uneven or the stress concentration. The wall in the external environment (temperature and humidity) under different influences under different stress, demonstrates the ability of anti-stress is not the same, and it will, with the passage of time, have a different change. In the course of time, the pressure will be accumulated to a part of the wall increased rapidly, the site became the

stress concentration area, when the wall structure cannot bear the stress, there will be cracks and wall discontinuity. At this point, the wall structure alleviates the internal pressure through the fracture, deformation.

2.3.2 Type of crack

Wall cracks are divided into different types according to different methods, the specific classification is shown in table 1.

Table 1: Types of wall cracks

Partitioning method	Type	Partitioning method	Type
Cracking depth	Surface cracks	cause	Load crack
	Transverse crack		Deformation crack
	Horizontal cracks		Temperature cracks
Manifestation	Longitudinal cracks	Influencing factors	Shrinkage crack
	45 ° miter crack		Settlement crack

3. Cause and analysis of cracks in filling wall of steel - concrete structure

3.1 External environmental factors

3.1.1 Temperature

The outer surface of the wall or the top of the wall is prone to irregular cracks. As a common material blocks are often used for the outer surface of the wall, and the top is mostly poured from the concrete.

The linear expansion of the two significant differences between the characteristics of the wall and the top of the junction, and the floor plate position in the internal and external temperature control Prone to pressure difference, with the constant increase of internal and external pressure difference, the building will be a fault or cracks. The linear expansion of the two properties are significantly different, so the cracks are often appeared at the junction of the wall and the top or the floor plate position because of increasing internal and external pressure difference. Especially in the summer, large indoor and outdoor temperature difference produce a larger outward expansion of the deformation to the floor, which makes the wall to produce lateral pressure, the wall was cut so that the wall from both ends of the central inclined oblique cracks. The walls are cut so that the wall appears from the ends of the tilt to the central slanting cracks (as shown in figure 1), especially at the top level on the gable ends.

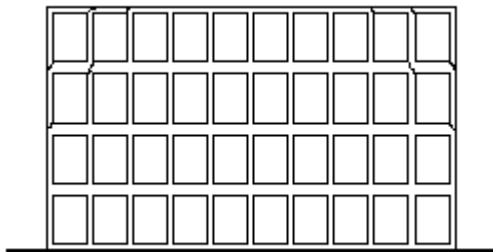


Figure 1: Slanting cracks

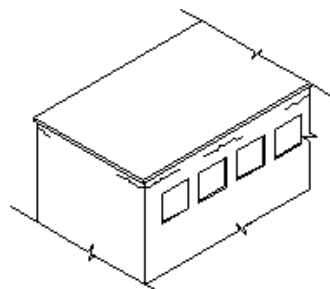


Figure 2: Horizontal cracks

As shown in Figure 2, cracks appear in the lower part of the gable, above the window, and extend from the roof to the sides. External wall produces shear stress due to increasing temperature. Because of the shear resistance of the wall itself, it is prone to appeared horizontal cracks in the window near the components, slanting cracks at the corner.

### 3.1.2 Uneven settlement of foundation

The causes of uneven settlement are as follows:

#### (1) The characteristics of the soil itself.

The foundation of the lower part of the building is composed of solid particles, water and air. The foundation in the upper load, will compress the soil between the pores, resulting in soil deformation and settlement. Under normal circumstances the soil pressure does not exceed  $600 \text{ KN/m}^2$ , the gap between the solid particles is small, in this case the deformation of the solid particles is small, almost negligible. So under the normal load, the reason of most foundation soil deformation is that solid particles in the pores of the air and water are squeezed out. Saturated soil and clay soil foundation cannot be compressed easily because of its lower porosity. The sand and gravel nature of the foundation, different from saturated soil, is not easy to be compressed but more prone to infiltration. Uneven soil foundation soil will cause the mixed compression of the soil, resulting in uneven settlement.

#### (2) Influence of adjacent foundation or load.

For example, the close distance between the adjacent buildings will cause the buildings' embedded depth difference and result in uneven settlement. In addition, when the prefabricated reinforced concrete piles are driven into piles in the soft soil foundation, the impact on the adjacent buildings will also be affected. In general, the effect will be greater with the distance from the piling site.

### 3.1.3 Humidity

Block in the transport process by the erosion of wind and rain, or in the construction site storage methods are not allowed, will make the block moisture content change. Especially in summer, material moisture content of the wall has risen because of rainfall and air humidity. Aerated concrete block is the most obvious wall material with humidity changes in the material. Once the block of water swelling, it will have its corresponding internal anti-expansion capacity. Block internal anti-expansion capacity is gradually weakened with the addition of external humidity. In this way, the block will produce uneven stress, making the tensile stress within the block increased, and then easily lead to wall cracks.

## 3.2 Internal factors

### 3.2.1 Block, mortar strength

Cracks will develop quickly when the strength of mortar and block does not meet the requirements or the mortar in the seam is not plump enough. But the shear strength of the wall material is inversely proportional to the bond strength. The higher the vertical bond of the wall material, the smaller the bond strength of the wall material is parallel to the wall material. The changes of the both are very difficult to be consistent and controlled.

### 3.2.2 The effect of shrinkage of materials

There are obvious differences in the basic properties of brick and mortar in building materials during the processing process, the solidification cycle, dehydration rate and post curing shrinkage. So the cracks in the construction are shown in different forms. And the wall body surface humidity change degree is small, the outside surface humidity change degree is bigger, so the dry shrinkage deformation by pulling force, leading to the surface crack. Because of different degree of humidity change between the outer and inner surface, the wall appears shrinkage deformation by tension, resulting in surface cracks.

### 3.2.3 The quality of the ash seam

The quality of the slit directly affects the wall quality. In the construction process, because the plaster mortar laying plumpness does not meet the specification requirements strictly, making the masonry tensile, shear capacity greatly reduced, and even lead to wall cracking. The quality of gray seam depends on whether the fullness and thickness of the slit meet the requirements. Factors affecting the degree of fullness are: block moisture content, mortar workability, operating methods.

## 4. Control measures of cracks in filling wall of steel - concrete structure

### 4.1 External environmental factors

#### 4.1.1 Temperature crack control measures

Setting the insulating layer and the insulating layer in the roof and exterior wall and the separating seam in the mortar layer cracks can control the temperature cracks effectively. Avoiding the high temperature season during the roof construction, choosing better thermal insulation materials, appropriately increasing the thickness of the insulation layer, light treatment for the outer surface of the roof will reduce the impact of

temperature. If necessary, the temperature difference should be simulated, and the thermal insulation layer should be arranged reasonably to reduce the temperature difference. The wall cracks can be prevented by setting the expansion joint owing to temperature difference between inside and outside. Generally expansion joints are located at the junction of the wall, the stress concentration area and so on. The spacing of expansion joints are as table 2 shown.

Table 2: The maximum spacing of expansion joint of masonry building

Category		Spacing /m
Assembled reinforced concrete structure	covering with insulation or insulation	50
	nothing	40
Reinforced concrete structure without purlins	covering with insulation or insulation	60
	nothing	50
Reinforced concrete structure with purlins	covering with insulation or insulation	75
	nothing	60
	Tile roof, wooden roof or floor, light steel roof	100

#### 4.1.2 Uneven settlement control measures

In order to prevent cracks caused by uneven settlement of foundation, special attention should be paid to the following points:

(1) Make geological survey well before architectural design.

In the geological exploration stage, we must take full account of the geological exploration of the many influencing factors. The samples must be able to reflect the authenticity of the sample. Especially in the selection of soil samples the characteristics of soil structure should be noted. If the soil is relatively uniform and stable, you can appropriately relax the sampling distance.

(2) Set settlement joint reasonably.

Settlement joints are generally located in the corner of the transfer of the building, the load or a large difference in height, structure or foundation of the Department, the settlement of soil and other parts of the foundation. Foundation conditions and building height determine the width of settlement. Settlement joint width requirements are as shown in the table 3.

Table 3: Width of settlement joint

Foundation properties	House height	Seam width (mm)
General foundation	<5m	30
	5~10m	50
	10~15m	70
Soft foundation	2~3 floors	50~80
	4~5floors	80~120
	>5 floors	>120
Collapsible loess foundation		$\geq 30\sim 70$

(3) Control the spacing of adjacent buildings strictly.

When the adjacent building structure is not in the same depth, the construction of deep buried foundation should be done after the shallow. In case of special circumstances, there must be a corresponding support program and effective technical measures. In order to avoid the mutual influence of adjacent buildings and the generation of stress superimposed area, the distance between adjacent buildings should meet the standard, which is shown in table 4.

Table 4: Distance between the adjacent buildings

Length to height ratio The estimated average settlements (mm)	$2.0 \leq L/H_f < 3.0$	$3.0 \leq L/H_f < 5.0$
	70~150	2~3
160~250	3~6	6~9
260~400	6~9	9~12
>400	9~12	$\geq 12$

#### 4.1.3 Humidity control measures

Controlling the moisture content of the block reasonably, can improve the mortar or block of compression, tensile, shear strength and bond strength. Besides, high water retention mortar can enhance the bond strength, reduce the probability of cracks. For building materials purchased in the market, the moisture content should be checked before use, and the curing period and the age of the materials should be clearly defined. The water content of the blocks should meet the specifications in table 5.

Table 5: Relative moisture content of small concrete hollow block

Area	Wet	Moderate	Dry
Maximum relative water content (%)	45	40	35

### 4.2 Control measures of internal factors of the wall

#### 4.2.1 Control block, mortar quality

Block is an important part of frame shear wall. Masonry materials must meet the various indicators, such as water content, softening coefficient, etc.. The quality certificate must be complete, and the factory age is not less than 28 days.

The quality of mortar is directly related to the strength of cement, and the cement of different standards should be chosen according to the application of the cement mortar. The configuration process should follow the principle of saving energy and reducing consumption, scientific allocation, as far as possible the use of low grade cement. The fluidity of mortar can also affect the quality of masonry, the fluidity of mortar is too large, and the mortar layer is easy to separate. On the contrary, if the flow is too small, and is not easy to operate, the mortar joints are hard to fill, so the new mixed mortar should have the appropriate consistency. Mortar consistency can refer to table 6.

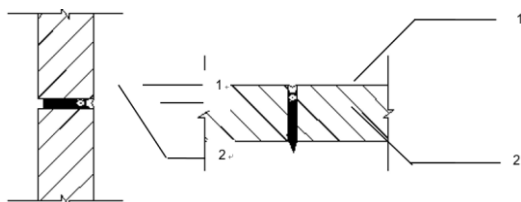
Table 6: Mortar consistency selection

Species	Mortar consistency /mm	Species	Mortar consistency /mm
Sintering ordinary brick masonry	70~90	Stone	30~50
Small hollow block masonry	60~90	masonry	
Sintered porous brick	60~80		

#### 4.2.2 Add detail structure to reduce shrinkage cracks

##### (1) Set the control seam

When the length of the building is large, vertical control joints can be set, the specific location can be located in the windowsill or window corner of the wall, the wall height or thickness of the sudden change. The specification stipulates that the width of the vertical control seam should not be less than 25mm, the filling material with good compression performance is sealed, and the external sealing material is sealed, and the non-absorbent, closed-cell foamed polyethylene solid round rod is used as the sealant separator. Control joint structure shown in Figure 3.



1-Foamed polyethylene solid round bars, 2- Soft filling

Figure 3: Control slot structure

##### (2) Increase the tensile reinforcement.

In order to reduce the shrinkage of the material and improve masonry shear strength, in the wall cracks and both sides of openings of the wall setting a certain number of anti-cracking reinforcement, steel mesh. When there is a door and window opening in the top wall, two or three welding reinforcing steel mesh or 2φ6 steel bars shall be set in the horizontal gravel on the cross beam and shall extend to not less than 600mm inside the two end walls of the hole. Window sills should embed in the window wall is not less than 600mm with use of reinforced concrete window sills. The wall corner and the vertical and horizontal wall junction should be set up knot reinforcement along the wall every 400 ~ 500mm, the number of each 120mm wall thickness should

not be less than 1φ6 or welded steel mesh, embedded in the length of the corner from the wall or junction , Not less than 600mm on each side. From the corner of the wall from the buried length or the intersection of counting, each side of must not be less than 600mm.

#### 4.2.3 Improve the quality of gray seam

The quality of masonry wall is directly affected by the quality of gray joint, which is controlled by the fullness and thickness of mortar. Masonry mortar wall must ensure full, horizontal and vertical. Thickness of the gray seam should be controlled between 8 and 12 mm and fullness of not less than 80%.

## 5. Conclusion

This paper analyzes the concrete causes of cracks in the frame filled walls of steel reinforced concrete structures caused by the temperature variation, uneven settlement of foundation, the influence of humidity and the strength of mortar, putting forward the concrete control measures, such as building insulation layer and setting expansion joints, to prevent the occurrence of cracks. The conclusion can provide a reference for the construction of steel - reinforced concrete infill wall.

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