

# Structural defects in residential buildings: A study of Quetta, Pakistan

**Zarak K Kasi<sup>1</sup>, Waqas A Mahar<sup>2</sup> and Jalal F Khan<sup>2</sup>**

<sup>1</sup>Department of Civil Engineering, Balochistan University of Information Technology, Engineering & Management Sciences (BUIITEMS) Quetta.

<sup>2</sup>Department of Architecture, Balochistan University of Information Technology, Engineering & Management Sciences (BUIITEMS) Quetta.

e-mail: [xarakkhan@hotmail.com](mailto:xarakkhan@hotmail.com), [architectwaqas@hotmail.com](mailto:architectwaqas@hotmail.com), [ar.jalalfaisal@gmail.com](mailto:ar.jalalfaisal@gmail.com)

## **Abstract**

Housing plays an important role in human life and in our society. Housing has a great social and economic impact on our lives and the way we live. It has direct and immediate effect on health, education, economy, environment, political and social life of any society. In today's technologically advanced world, the quality of housing and its maintenance in a liveable condition yet remains a challenge in many parts of the globe. This study identifies the various types of structural defects present in the residential buildings of Quetta city. The data was collected from selected areas of the city using questionnaire, physical identification survey, and conducting interviews based on the fundamental knowledge of structural defects and their effects on buildings. It was found that houses in Quetta cantonment area possess the highest number of structural defects followed by Pashtoonabad area. Apart from identifying the most affected area, an overall state of the residential buildings in Quetta city regarding structural integrity was also determined. Since, the city of Quetta is in earthquake zone, it is very important that these types of structural defects should be avoided in future residential buildings and necessary maintenance should be carried out in existing houses to avoid any serious damages to houses and loss of human lives due to the occurrence of any possible disaster.

**Keywords:** Housing survey, Structural defects, Residential buildings, Building safety, Quetta

## **1. Introduction**

In our urban and social life housing plays a significant role and it reflects our identity, health, well-being, and socio-economics status (Alnsour, 2011) (Gibson, et al., 2011). In the age of globalization, with the development of many fields housing and construction industry is also growing rapidly. The growth is occurring due to several reasons which includes the increasing population, technological development, professionals, and skilled people who are involved in housing and construction sector. However, there is still a lot to be done in housing sector; we still find poorly designed houses. Several countries are still facing the challenges and problems like lack of policies, poor planning and design, improper facilities and services, unaffordability of housing, housing shortage, unavailability of low cost housing etc. We also know that a good house or living facility improves the quality of life while a faulty and poorly designed house do not fulfil the demands of its inhabitants (Mahar, 2012).

Building defects is also one of the major problem in the houses and it takes a good amount of housing maintenance to fix the defects. Moreover, these defects may cause various complications for the residents of the house which might lead to the damage to the property or human life (Mahar, 2012). It is important to fix the building defects and carry out the necessary maintenance work for the proper functionality of a building. However, this subject has been ignored in Balochistan since long. (Kasi, 2017). Very little or no information is available on the housing and construction sector of Quetta and most of it is outdated (Mahar, Knapen, & Verbeeck, 2017). In addition to design, material and construction deficiencies, the building defects also occur in Quetta due to its specific climate conditions (Kasi, 2017).

Buildings defects and their maintenance is one of the major repair work in houses, unfortunately little or no work has been done in this subject in Balochistan and specially in Quetta. Since Quetta lies in earthquake zone it is important to identify the building defects in general and particularly in residential building to perform necessary maintenance work and avoid losses of human lives and shelters in the unexpected occurrence of disasters. When a building material or component do not perform or act as it should, there is a need to look for the reasons. Is there an issue caused by design or construction? Or due to using substandard material? Did the same problem occurred in the past and was it fixed or not? The suitable responses often depend on some variables: the nature of the problem, the age of the influenced segment, human error, or combinations of the three.

The study aims to identify the common structural defects in residential buildings of Quetta and it can be helpful in future for the development of building maintenance and inspection codes for the city of Quetta which will eventually benefit to save the loss of property and human lives. The paper presents the introduction including study area, literature review about defects, methodology adopted for this study, finding of the study and in the end conclusion and recommendations are added for further research.

### **1.1 The study area**

Quetta is the 10<sup>th</sup> largest city of Pakistan and provincial capital of Balochistan with an urban population of over 1 million (PBS, 2017). Due to its geographical location the city is a major trade and communication centre between Afghanistan and Pakistan. Quetta city constitutes the cantonment and metropolitan area of Quetta district (Mahar, Knapen, & Verbeeck, 2017). The weather of Quetta is arid and dry with mild to extreme cold in winter and hot summer. The city also receives snowfall, mainly between the months of December, January, and February. The annual rainfall is low as Quetta do not fall under monsoon region (P&D, 2011). The weather in Quetta have substantial variations during summer and winter. The extreme recorded temperatures in Quetta are -18.3 °C in 1970 and 42 °C in 1998 (PMD, 2018). Such temperature variations may result in building defects such as development of residual stresses due to contraction and expansion of the concrete, freezing and thawing of concrete, concrete plaster damage and freezing and breakage of water and sewage lines etc.

There is no code or regulations for the maintenance of housing stock in Balochistan. Structural defects in Quetta are one of the major issue. No measures have been taken by the government, development authority or municipality to create the awareness regarding structural defects and their adverse effects on the property and human lives. Adobe structures yet exists in some of the areas in Quetta and their dwellers are unaware of the safety condition of their dwellings. Several incidents occurred due to ignorance of maintenance in Quetta. 4 people died including 3 siblings when a mud house collapsed in Betni Colony, Nawa Killi Quetta on 26<sup>th</sup> January 2017. In another incident on 29<sup>th</sup> January 2016 2 children died due to the roof collapse in Kasi road area (Kasi, 2017).

## 2. Literature Review

In several cases it is noticed that the number of defects and rework is higher in the smaller houses (Sommerville, 2007). Minor defects may occur due to the construction process and nature of the building. The defects only become a problem if they are excessive or major (Ong, 1997). There are several definitions of defects; but perhaps the simplest is provided by the *Oxford English Dictionary*, “a short coming or failing short in the performance of a building element”. This definition has also been legally validated (Dorter & Sharkey, 1990). According to Webster's Dictionary, ‘defect’ is defined as the absence of something vital for completion; an inadequacy. It is likewise characterized as an imperfection, fault, or flaw (Ahzahar, Karim, Hassan, & Eman, 2011). Building defect is one of the major components of building problems that needs significant attention (Bakri & Mydin, 2014). (Georgiou, Love, & Smith, 1999) has divided defects in three categories:

- (1) *Technical*. A defect caused when the materials or building elements do not meet or reduce their functional performance. Technical defects may cause damage to human life and assets. The diagnosis of such defects might need some scientific tests and investigation.
- (2) *Aesthetic*. A defect which adversely affects the appearance of the building material or element. Defects like discolouration, dampness, corrosion, efflorescence, plaster or tile delamination, broken glass or graffiti are considered aesthetic defects. These defects usually affect the visual appearance and beauty of the building and might lead deterioration of the building materials or elements in some cases. Such defects may not harm the asset, structure and human life and need less amount to be fixed.
- (3) *Functional*. A defect which lead the building failure to function as it was planned and designed. These defects are related mainly with planning, design, and location of the building.

This study is mainly concerned with the first category of defects and particularly structural defects. No scientific investigation was performed to find out the severity of the defects due to lack of time and resources. The study is mainly based on basic knowledge and understanding of the defects as per the available literature. Mahar (2012), mentioned that the reporting of defects can be done by two ways: i) Stock condition survey which includes questionnaire and physical observation and ii) day-to-day survey. The first method was used for this study.

Internationally housing stock surveys are conducted at various levels to facilitate or guide the residents for the necessary maintenance in their houses. There are also codes for the building and property maintenance such as International property management code (IPMC) or International Building Code (IBC) (Council IC, 2000). Kasi (2017) discussed various defects which occurs during design, planning, review, construction, supervision, and development of a building. However, the focus will remain on the structural defects.

### *2.1 Structural defects*

The structural defects which were included in this research are as following:

#### *2.1. Defective concrete, loose plaster or spalling in roofs/ceiling*

Such defects occur due to water seepage or water leakage from the roof slab. These defects cause bulging, pattern cracking, falling off clear cover from concrete which would expose the reinforcement. The reinforcement gets rusted by corrosion effect; water leakage may also react with adjacent walls which might cause plaster or tile delamination. The spalling of roofs is shown in Figure 1.



Figure 1. Spalling of roofs

#### *2.2 Water seepage from wall, window, roof, or from ceiling*

Cracking in external walls may cause water seepage which would result in water stains, peeling off and discolouration of paint or wall paper, water dripping and the growth of fungus. This would in turn cause defects in concrete (permeable) and in plaster or tiles. The stains in structures as shown in Figure 2 can be a cause of water seepage and may occur due to several reasons including cracks on external wall, honeycomb, defective concrete, defective windows, waterproofing membrane at roof etc.



Figure 2. Stains in Structures

#### *2.3 Structural cracks*

Structural cracks may occur due to several reasons including settlement of soil, foundation, overloading, poor design, and construction or use of substandard materials etc. The cracks shown in the Figure 3 produce cracks which penetrate through finishes into the bricks, long cracks across width of the wall, diagonal cracks at corners of window or door and cracks with rust staining.



Figure 3. Structural cracks found in doors and windows

#### *2.4 Structural cracks in frame*

These cracks may produce due to same reasons as explained in 2.3. Cracks, shown in Figure 4 are formed in the columns and beams and produce spalling as well.



Figure 4. Cracks found in Beams due to excessive loading

#### *2.5 Non-structural cracks (usually in plaster or other finishes with cements and rendering as base)*

This type of cracks are usually aesthetic cracks and do not possess any safety concern. This type of cracks includes multi-directional cracks (shrinkage cracks), hairline cracks, and cracks between panel walls and structural elements.

#### *2.6 Defective wall finishes/tiles/stone cladding*

These defects may occur due to ageing, defective workmanship, thermal movement in expansion joints or by external factors such as falling parts as shown in Figure 5. This would result in de-bonding and delamination of finishes/ tiles from structure and when tapped with a hammer results in a hollow sound. Other defects are falling off and loosening of parts.



Figure 5. Falling off Plaster found in Walls

### 3. Methodology

The case study research approach was adopted for this research. As mentioned earlier in literature review, stock condition survey was used for data collection and survey. A survey questionnaire was developed for collecting necessary information, additionally physical observation survey (visit) was done to understand the defects. Semi-structured interviews were also conducted to get insights regarding the problem of defects and understand the opinion of residents. The gathered data was then compared with the literature review which includes the building standards and codes regarding structural defects to analyse the existing safety of the structures. The primary data was analysed considering the aim to find out the reasons behind the occurrence of common structural defects in residential buildings.

It is important to select the residential areas which are most representative and represent the most common housing typologies, construction materials, ethnic and income groups, and the type of housing; i.e. slums, public housing, planned areas and housing developments etc. According to Quetta Development Authority (QDA), the residential areas in Quetta makes up to 60% of the total city area. For this study, according to the geographic location of Quetta city, the residential zones were divided into 8 localities and several residential areas as shown in Table 1.

Table 1. Selected areas for research

Locality	Residential Areas
Balochi Street	Balochi Street, Kasi Killa, Prince Road, Masjid road, McConaughy Road
Brewery Road	Wahdat Colony, Railway Housing Scheme, Golli Mar Chowk, A-1 City
Chaman Housing Scheme	Chaman Housing, GOR Colony, Abdal Colony, Killi Shabo
Chiltan Housing Scheme	Chiltan housing Scheme, Killi Almas, Chashma Achozai
Jinnah Town	Arbab Town, Kakar Town, Jinnah Town, Shahbaz Town
Pashtoonabad	Pashtoon Dara, Afghan Road, Kachra Road, Taro Chowk
Quetta Cantonment	Gulitsan Road, Madrasa Road, Chiltan Market, Global Centre, Tail Gudam and Mariabad
Satellite Town	Mini Market, Phase 1, Phase 3, Chandni Chowk, Kakar Colony

Due to the limitation of time 50 houses were selected by random sampling for the data collection. Considering the several factors; such as, housing typology, income and ethnic groups, construction pattern and materials, consent of the owner etc.

The survey questionnaire includes questions on demographics, construction, and materials, defects, and their repair or maintenance. To get a complete picture, the questions were asked on the age of the building, type of structure, type of finishes etc. Furthermore, interviews with the house owners were conducted to understand the level of satisfaction of the dwellers with the construction type and quality, psychological effects of defects on dwellers, their perception and understanding about the defects and the risks or hazards of the structural defects exist in the building, and the defects which have been taken care of by the dweller.

### 4. Results & Discussion

This section presents the results of the structural defects and problems found in 50 residential buildings in Quetta. The results are divided in three categories for better understanding; i.e. i) housing type, age, and maintenance, ii) Common deficiencies and iii) Defects in residential buildings.

#### 4.1. Housing type, age, and maintenance

Most of the people in Quetta are living in houses and less likely choose to live in apartment buildings. The results show that building system in residential areas of Quetta mainly represent detached, semi-detached houses and apartments, see Figure 6.

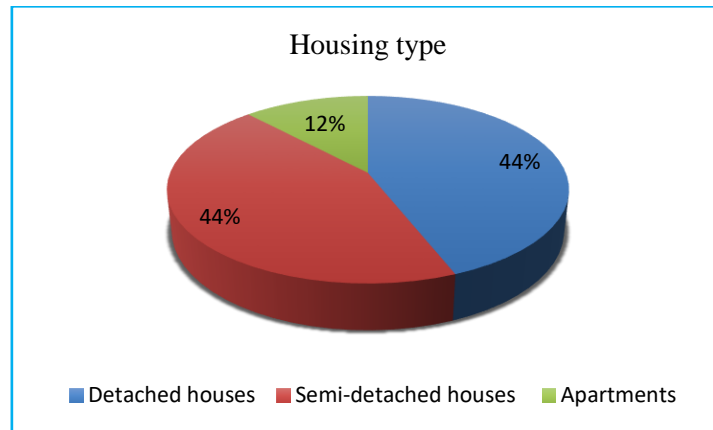


Figure 6. Housing type in the survey

The age of a building shall also be considered to have a better understanding of the structural defects. The age of building can be a primary factor in the deterioration and occurrence of defects in the buildings, especially the cracks may be produced due to the prolonged effects of the loads (Figure 7).

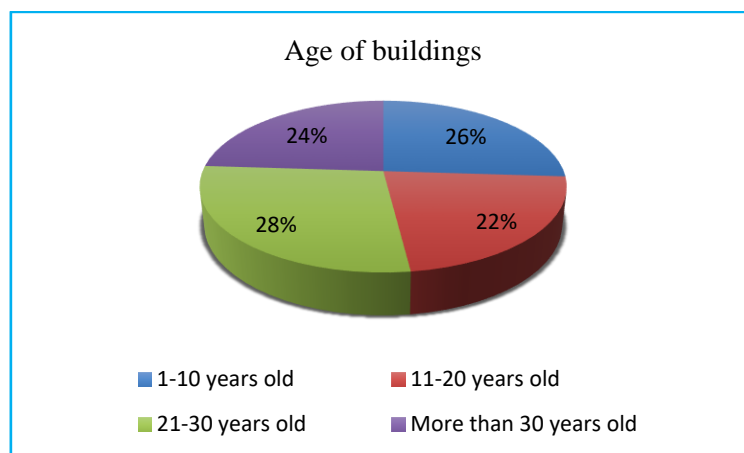


Figure 7. Age of the buildings

The frequency of defects and their occurrence after specific time is an important aspect. This can be helpful to propose and carry out the maintenance work for the houses. Some defects might occur frequently, and some occur after specific time. In our sample most of the houses (figure. 8) needed some maintenance and repair work within 2-5 years after the construction of the house, i.e. 40%.

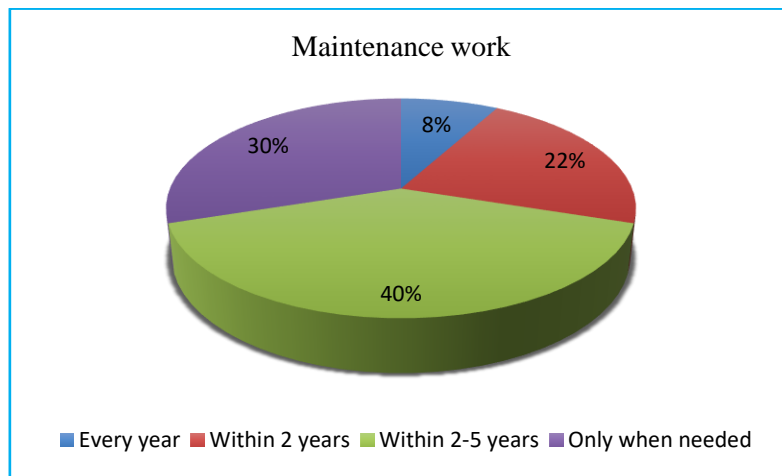


Figure 8. Maintenance work carried out in houses by time

#### 4.2 Common deficiencies

The common type of deficiencies considered for this study includes; design, material, and construction deficiencies. Sub surface deficiencies were not included as it need further detailed analysis using scientific tools and methods. The results show that one building have one or more type of deficiencies, figure 9.

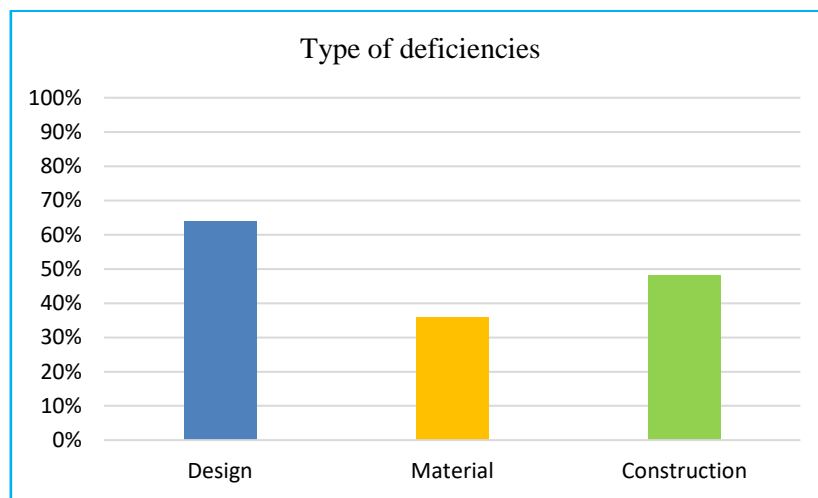


Figure 9. Type and percentage of deficiencies

Design deficiency contributes to the greatest number of defects, about 64% of design deficiencies were found in the selected houses in Quetta. The typical design deficiencies found were: cracks in slabs; leakages from walls and roofs; cracks in the structural elements. The design deficiencies occur due to overstress of structural elements which produce cracks. When the rebar is subjected to tension, they will stretch, thus the concrete covering the reinforcement will stretch and produce cracks.

The material deficiency was found in 36% of the houses. This occurs when the materials unable to withstand the external environment and elements used to enthrall these external variables leak because of material failure. Materials such as, mortar, concrete, steel, concrete blocks, glass, plastic etc. may get faulty during preparation or production process. Concrete, is delicate to material failure as it contains several ingredients and each ingredient influences its durability and strength. Care should be taken during the selection of materials and quality must be checked in order to use best materials for the construction of buildings.



Construction deficiencies found in this study account 48% of the houses. Poor workmanship may result in construction deficiencies causing stain and mould growth, plumbing leaks, wood rotting etc. in buildings. The construction deficiencies may occur due to several reasons, such as, water addition to concrete in order to increase slump which will decrease its strength, improper framework, improper consolidation of concrete, improper curing of concrete, improper placement of reinforcement, formwork movements, concrete settling, subgrade settling etc.

#### 4.3 Defects in residential buildings

##### 4.3.1 Defective concrete, loose plaster or spalling in roofs/ceiling

Questions were asked about the construction of roof and roofing materials. From the obtained data the defects from defective concrete, cracks in roof and or spalling are presented in Figure 10.

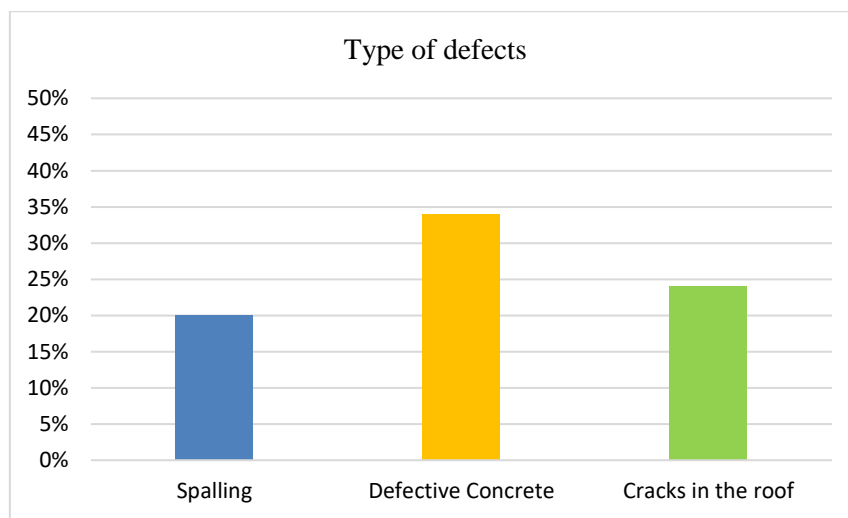


Figure 10. Percentage of defective concrete, spalling and cracks in the roof

Majority of the houses, i.e. 78% in sample size were built of reinforced cement concrete (RCC) structure and only 17 houses showed the symptoms of defective concrete accounting for only 34% of the overall percentage. The concrete may get defective due to water leakage from the plumbing (construction deficiency) or due to the use of substandard or inappropriate materials (material deficiency). Patching process can be used to tackle the defective concrete by cutting off or hacking down and it can be replaced.

Spalling was found only in 20% of the houses, which might have occurred due to overloading of the element (design deficiency) or because of the usage of salty water in concrete mix (construction deficiency). To fix the spalling problem concrete may be torn off to check the reinforcement for rustiness and if it is insufficient for use then reinforcement can be replaced. Structural and load calculations may be required to complete this process. Houses in Quetta cantonment area found more affected by spalling, Table 2. One of the reason is could be the age, since 30% of the houses (as per sample) in cantonment area were constructed 20-30 years ago and 20% of them were more than 30 years old. Another possible reason is the location of City Nallah which passes close to some of the areas located in cantonment.

Table 2. Percentage of spalling found in different areas

S. No.	Name of the locality	Houses affected by spalling (%)
1.	Chiltan Housing Scheme	20
2.	Jinnah Town	10
3.	Pashtoonabad	40
4.	Quetta cantonment	60

#### 4.3.2. Water seepage from walls, windows, roof, or from ceiling

To understand the causes of seepage or leakage of water in building it is important to know the composition and construction of building elements. Data was gathered regarding the construction of walls and its finishing materials in addition to the roof as mentioned in 4.3.1. The following Figure 11, provides us an overview of the defects such as, water seepage from walls and roofs found in the houses during our survey.

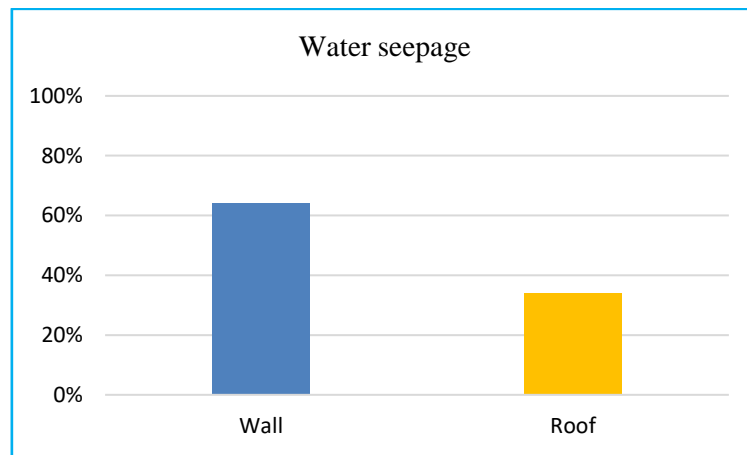


Figure 11. Water seepage percentage found in walls and roofs

Cement plaster is the most common type of wall finishes found in the survey representing 60% and the main material of the walls was backed bricks 68%. The seepage from roof was found in 34% and from walls in 64% of the houses. The seepage from roof or walls may occur due to plumbing leaks (construction deficiency), defective concrete, deep cracks found in the wall and defective finishes which are used protect the building from rain seepages.

The localities namely of Balochi Street, Chiltan Housing Scheme and Jinnah town found more affected by seepage problem (table 3). The houses surveyed in the locality of Balochi street had one common wall, i.e. semi-detached houses which could be one of the reason for high percentage of water seepage. Another reason can be water penetration in surfaces through capillary action from soil or ground which may occur due to leakages in sewerage lines. The same can be a reason in Jinnah Town area as well. The reason of water spillage in Chiltan housing scheme is because construction of buildings being carried out in the area which was occupied by rain water streams in the past. While the water seepage from roof is caused by plumbing leaks, improper roof drainage slopes, defective concrete, and improper structural design.

Table 3. Percentage of water seepage from walls and roof for different areas

S. No.	Name of the locality	Seepage in walls (%)	Seepage in roof (%)
1.	Balochi Street	100	60
2.	Chaman Housing Scheme	20	
3.	Chiltan Housing Scheme	80	60
4.	Jinnah Town	80	10
5.	Pashtoonabad	40	40
6.	Quetta cantonment	40	60
7.	Satellite Town	60	40

The plumbing leaks can be fixed by fixing the leaked pipes between the walls and the roofs. The cracks developed due to water leakage can be fixed by injecting chemicals and repairing them with water proofing mortar. Whereas the defective concrete such as honey combing of concrete should be removed and replaced by water proof mortar.

#### 4.3.3 Defective wall finishes, Stains and Fungus on walls

The defects in this category mainly occur due to the absorption of water or seepage from an external source or environment. It may cause moisture in surfaces, discolouration of paint, plaster, and tile delamination etc. nearly half of the houses were found affected by this type of defects as mentioned in figure 12.

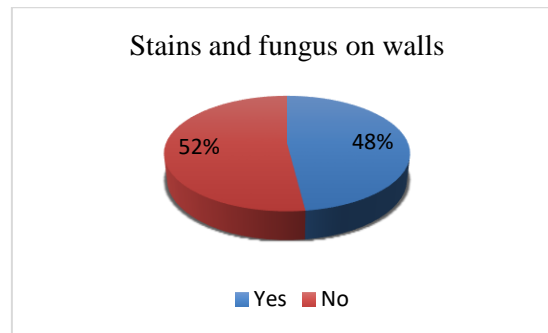


Figure 12. Percentage of Stains and Fungus found on the walls

The stains and fungus were found in 48% of the houses. The stains are caused by water seepage which may enter in the building from its roof or walls. Some factors provide favourable environment for the growth of stains or fungus on surfaces which may also include temperature variations between indoor and outdoor climate. Table 4, presents the overall picture of stains and fungus found in houses situated at different localities.

Table 4. Stains and Fungus found in different areas

S. No.	Name of the locality	Houses affected by stains and fungus (%)
1.	Balochi Street	80
2.	Chaman Housing Scheme	60
3.	Chiltan Housing Scheme	60
4.	Jinnah Town	10
5.	Pashtoonabad	40
6.	Quetta cantonment	90
7.	Satellite Town	40

City Nallah is near Quetta cantonment which could be a cause of moisture in buildings and provide suitable environment for the growth of fungus and stains. On the other hand, the water table is also high in cantonment area compared to other nearby localities. The orientation of the houses also affects the growth of stains and fungus, such as no direct sunlight exposure of building surfaces and improper

ventilation which helps the contamination of moisture for long time resulting in the growth of fungus. This was one of the reason in Balochi street area which caused fungus and stains in the houses.

There are serval types of micro-organisms which can grow in the structure and different types of algae growth have different remedies. Some stains can be removed by using sodium hydrochloride solution which can be made up of chlorine bleach whereas in some cases cold water and cleaning with a brush can do the job. Apart from this, water proof membranes should be used in construction of buildings near such parts of the building.

#### 4.3.4 Cracks

##### 4.3.4.1 Structural cracks

Structural cracks may occur due to soil settlement and are formed on the walls in diagonal directions. The data obtained from the questionnaire provide an overview about structural cracks found in the residential buildings of Quetta, Figure 13(a). These cracks were further classified as: very wide cracks, medium sized cracks, and hairline cracks. As presented in figure 13(b) majority of the cracks are hairline cracks, i.e. 50%.

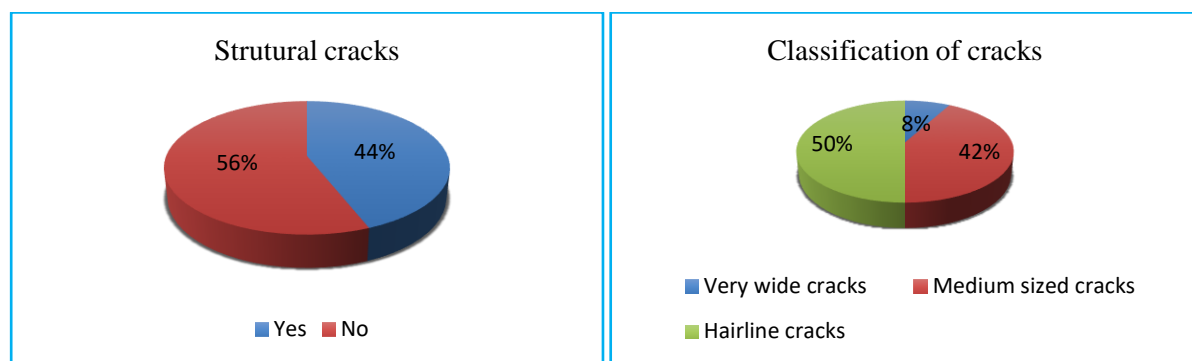


Figure 13(a) Structural cracks

Figure 13(b) Classification of cracks

Structural cracks were found in 44% of the residential buildings. These cracks penetrate through walls and finishes and were also found diagonally on doors and windows. Structural cracks may appear due to structural movement, soil settlement, weakness of structure caused by rusting or corrosion, overloading, or acid attack on concrete. Such problem need to be thoroughly investigated before repairing these cracks.

The high percentage of strutural cracks were found in the areas of Balochi Street, Quetta cantonment, Brewery road, and Pashtoonabad localities (Table 5). Several houses in Quetta are built without designing architectural plans and structural loads and the construction work is executed by people with inadequate knowledge and professional background. A good number of houses, i.e. 40%, needed repair and maintenance within 2-5 years of their construction. The repair of these cracks can be done by grouting, opening, and refilling it with concrete (patching), or using epoxy resins.

Table 5. Structural cracks found in different areas

S. No.	Name of the locality	Structural cracks in houses (%)
1.	Balochi Street	80
2.	Brewery Road	80
3.	Chaman Housing Scheme	40
4.	Chiltan Housing Scheme	20
5.	Jinnah Town	10
6.	Pashtoonabad	80
7.	Quetta cantonment	80
8.	Satellite Town	40

#### 4.3.4.2 Structural Cracks in Frame

The structural crack in frame can be dangerous and cause some spalling in the beams and columns which may lead to structural failure and cause damage to the property and the human lives. In our study 18% of the houses found with structural cracks in the frame of the building (figure. 14)

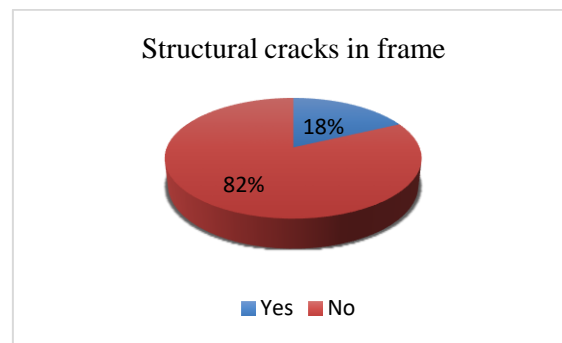


Figure 14. Percentage of cracks in frames

In the survey, 92% of the houses possessed the frame structure using beams and columns. Structural cracks in frames have the same causes as explained in section 4.3.4.1. They may also occur due to the use of substandard materials, design and construction deficiencies, settlement of ground, and damage by accidents etc. It is important to identify and understand the actual cause of these defects before fixing the cracks in building frame. These cracks may also be repaired as mentioned in the section 4.3.4.1. If the cracks are big enough and the reinforcement is affected, then section should be changed with respect to proper structural design calculations. Houses in Quetta cantonment found with higher percentage of structural cracks in the frame (Table 6). 30% of the houses (as per sample) in cantonment area were built 20-30 years ago and 20% of them were built more than 30 years ago. The repair work carried out in the houses was also inadequate to fix the problem.

Table 6. Structural cracks in frame found in different areas

S. No.	Name of the locality	Structural cracks in frames: houses (%)
1.	Balochi Street	20
2.	Pashtoonabad	20
3.	Quetta cantonment	70

#### 4.3.4.2 Non-structural cracks

This type of cracks affects the aesthetic beauty and visual appearance of the buildings. 76% of the houses were found with non-structural cracks in our survey. Such type of cracks may occur due to defective concrete, construction and material deficiency, poor workmanship, improper curing of plaster, accidental damage, and by peeling off the paint etc. The percentage of non-structural cracks

found in different areas is presented in Table 7. Non-structural cracks can be fixed by applying plaster or epoxy resins to cover these cracks.

Table 7. Non-structural cracks found in different areas

S. No.	Name of the locality	Non-structural cracks found in houses (%)
1.	Balochi Street	100
2.	Brewery Road	80
3.	Chaman Housing Scheme	60
4.	Chiltan Housing Scheme	100
5.	Jinnah Town	70
6.	Pashtoonabad	40
7.	Quetta cantonment	90
8.	Satellite Town	60

To summarize the results the identified defects and their percentage found in each locality are given in table 8. As per the results of collected data more defects were found in the houses located in Quetta cantonment area compared to other areas and localities.

Table 8. Overview of the defects found in each locality

Type of defects	Balochi Street (%)	Brewery Road (%)	Chaman Housing Scheme (%)	Chiltan Housing Scheme (%)	Jinnah Town (%)	Pashtoonabad (%)	Quetta Cantonment (%)	Satellite Town (%)
<b>Cracks</b>								
Structural cracks	80	80	80	20	10	80	80	40
Str. Cracks in frame	20					20	70	
Non-structural cracks	100	80	60	100	70	40	90	60
Cracks in roof	20		20		10	40	70	
<b>Water spillage</b>								
Walls	100	100	20	80	80	40	40	60
Roofs	60			60	10	40	60	40
Defective concrete	60			60	10	40	60	40
Spalling				20	10	40	60	
Fungus, Stains	80		60	60	10	40	90	40

## 5. Conclusion & recommendations

The city of Quetta is the only urban city of Balochistan province. With the growing population the demand of building and construction industry is also growing. There is a need of proper design and supervision in addition to the strict implementation of bylaws, building codes and regulations at local level. It was found that the construction work of most of the residential buildings was carried out by unqualified and unprofessional team. The residents of the house were usually unaware of the defects and their causes. They also had no idea about the safety hazards and the possible damage some defects might cause. Most the people were reluctant to diagnose and fix the defects.

The study presented and categorized the structural defects found in different localities and residential areas of Quetta city. These defects also highlight the real condition and situation of housing stock in different areas. Some defects occur in a specific locality or vicinity while other defects can be found in more or all residential areas. The study shows that houses located in Quetta cantonment areas were mainly affected by all kinds of defects discussed in this study. The locality of Pashtoonabad comes next after Quetta cantonment and all sort of identified defects were found in both localities. Non-structural cracks, was the most common defect and then water spillage from the walls, both defects were found in all localities of Quetta city selected for this study.

It is inappropriate to make conclusions about the overall housing conditions and defects in Quetta based on this study and there is a need to further investigate the subject with a scope to cover majority of the residential areas and having a large sample size of the houses. Studies regarding substructure defects should also be carried out in order to determine the construction quality of the buildings. There is a need to create awareness and transfer knowledge regarding the construction of houses, quality of construction and building defects to help the dwellers to understand the risks related to building safety and maintenance.

## References

- Ahzahar, N., Karim, N., Hassan, S., & Eman, J. (2011). A study of contribution factors to building failures and defects in construction industry. *Procedia Engineering*, Vol. 20, pp. 249-255.
- Alnsour, J. (2011). Illegal housing in Jordan. *Jordan Journal of Social Sciences*, Vol. 4, pp. 339-354.
- Bakri, N., & Mydin, M. (2014). General building defects: causes, symptoms and remedial work. *European Journal of Technology and Design*, Vol. 3(Issue. 1).
- Council IC, O. B. (2000). International Building Code 2000. Dearborn Trade Publishing.
- Dorter, J., & Sharkey, J. (1990). *Building and Construction Contracts in Australia*. The Law Book Company, Sydney, Australia.
- Georgiou, J., Love, P., & Smith, J. (1999). A Comparison of Defects in Houses Constructed by Owners and Registered Builders in Australian State of Victoria. *Structural Survey*, Vol. 17(Issue: 03), pp.160-169.
- Gibson, M., Petticrew, M., Bambra, C., Sowden, A., Wright, K., & Whitehead, M. (2011). Housing and health inequalities: a synthesis of systematic reviews of interventions aimed at different pathways linking housing and health. *Health & Place*, Vol. 17, pp. 175-184.
- Kasi, Z. K. (2017). *A Case Study of the Structural Defects in Quetta with Focus on Residential Buildings*. Master Thesis M.S Civil Engineering, BUITEMS Quetta, Pakistan.
- Mahar, W. A. (2012). Defects on building facades in Desa Bakti employee housing, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia. Master Thesis M.Sc. (Planning-Housing), Faculty of Built Environment, Universiti Teknologi Malaysia.
- Mahar, W. A., Knapen, E., & Verbeeck, G. (2017). *Methodology to determine housing characteristics in less developed areas in developing countries: A case study of Quetta, Pakistan*. European Network for Housing Research (ENHR) Conference 2017, Tirana, Albania.
- Ong, S. E. (1997). Building Defects, Warranties and Project Financing From Pre-Completion Marketing. *Journal of Property Finance*, Vol. 08(Issue: 01), pp. 35-51.
- P&D. (2011). *Quetta: District Development Profile*. Planning & Development Department, Government of Balochistan.

PBS. (2017). *Population & Housing Census*. Pakistan Bureau of Statistics (PBS), Government of Pakistan.

PMD. (2018, February 26). *Quetta Historical Temperature data*. Retrieved from Pakistan Meteorological Department : <http://www.pmd.gov.pk/cdpc/extrems/QUETTA.htm>

Sommerville, J. (2007). Defects and Rework in New Build: An Analysis of the Phenomenon and Drivers. *Structural Survey*, Vol. 25(Issue: 05), pp. 391-407.