# Defects in Affordable Housing Projects in Klang Valley, Malaysia

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**Abstract:** Several affordable housing programs were introduced by the government of Malaysia to achieve the objectives of several plans; however, the success of the housing programs was reduced because of reported quality problems and defects. This research aims to identify the types of defects in affordable housing and to determine what is causing the defects, so that solutions may be devised to raise the quality of housing stock in Malaysia. A questionnaire survey was distributed to 310 residents in affordable housing, located in four different regions of Klang Valley, Malaysia. The most commonly occurring defects in affordable housing were leaking pipes, total failure of water supply systems, cracking in concrete walls, faulty door knobs, and concrete walls dampness. This suggests that improvements in workmanship, use of superior materials, and changes to more customer-oriented supervision and monitoring may reduce the incidence of defects. Local conditions, such as heavy rainfall, may influence dampness, and may reduce the generalizability of findings to other areas with different weather patterns. The findings have been reported to the Construction Industry Development Board of Malaysia to improve the quality of affordable housing.
**DOI:** 10.1061/(ASCE)CF.1943-5509.0000413. *© 2014 American Society of Civil Engineers.*

**Author keywords:** Defects dissection; Low-cost housing; Affordable housing; Building defects; Building quality.

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## Introduction

Low-cost housing has always been criticized for poor quality and defective outcomes (Abdellatif and Othman 2006). Rinker (2008), in his report on affordable housing issues, pointed out that public housing projects have deteriorated badly because of a combination of hasty construction, poor design, and insufficient maintenance. Frequently, customers and end-users of low-income building projects complain that their accommodations do not meet their expectations and are not designed to suit their requirements (Abdellatif and Othman 2006). Construction defects could be caused by substandard construction strategies, faulty workmanship inside and outside the house, bad building materials, improper soil analysis, and poor preparation or poor drainage systems (Auchterlounie 2009). Construction defects could also be the result of improper design or installation deficiencies. One of the most common problems faced by house purchasers in Malaysia is the substandard construction of houses (Sufian and Abdul-Rahman 2008). Despite the Malaysian government's commitment to providing adequate, affordable, and quality houses for all income level groups, with emphasis on the development of low-cost housing, there continue to be challenges in developing the housing sector (Ariffian et al. 2010). The low-cost housing provided does not meet the demands of low-income groups. Many of these problems are related to the poor quality of workmanship and inadequate supervision during construction (Trevor 2009). Low- and middle-income housing has also been shown to have a variety of defects in Malaysia. There has also been a widely reported case, in which the residents from the Rista Villa apartments, in Taman Putra Perdana, complained that there were huge cracks appearing at the bottom of the apartment building; the situation become worse with the completion of the South Klang Valley Expressway (SKVE).

Substandard housing and defective construction may be caused by several factors. Ong (1997) reported that developers show less incentive to furnish quality housing, particularly in terms of workmanship, if their real estate assets are sold before completion. Accordingly, their reduced efforts lead to more defective construction and subject house purchasers to a greater degree of housing defects. Holmstrom (1979), Rogerson (1985), and Shavell (1979) have asserted that "Build, Then Sale" discourages developer efforts. House purchasers must also rely on architects to supervise the quality of their house construction. Because architects are frequently employed by the developers, home buyer skepticism of their credibility is not surprising (Sufian and Abdul-Rahman 2008). Therefore, house purchasers often face difficulties in evaluating the physical construction quality (Forsythe 2008).

Klang Valley is a region on the peninsula of Malaysia that comprises the capital city of Malaysia, Kuala Lumpur, and surrounding suburbs (Fig. 1). Also known as the Kuala Lumpur conurbation, it is the fastest growing region in Malaysia (Teck-Hong 2011), and has a population of approximately 7.2 million in an area of approximately 3,200 $km^2$. Klang Valley is a low-lying area (Zain-Ahmed et al. 1998) that begins in the north-east of the Kuala Lumpur, and is an area with many major towns, including Petaling Jaya, Subang, Shah Alam, and Klang. As reported by the Ministry of Finance's Valuation and Property Service Department (2009), more than 45% of houses recently constructed in Malaysia are located in the Klang Valley. Because of the importance of affordable housing in this rapidly growing region, the goal of this study is to identify the types and causes of frequently occurring construction defects in affordable housing in the Klang Valley, Malaysia.

## Affordable Housing in Klang Valley, Malaysia

Affordable housing is defined as appropriate housing units for which the construction is in accordance with standards and complies with

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Note. This manuscript was submitted on September 13, 2012; approved on October 23, 2012; published online on October 25, 2012. Discussion period open until September 1, 2014; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Performance of Constructed Facilities***, Vol. 28, No. 2, April 1, 2014. ©ASCE, ISSN 0887-3828/2014/2-272–285/$25.00.

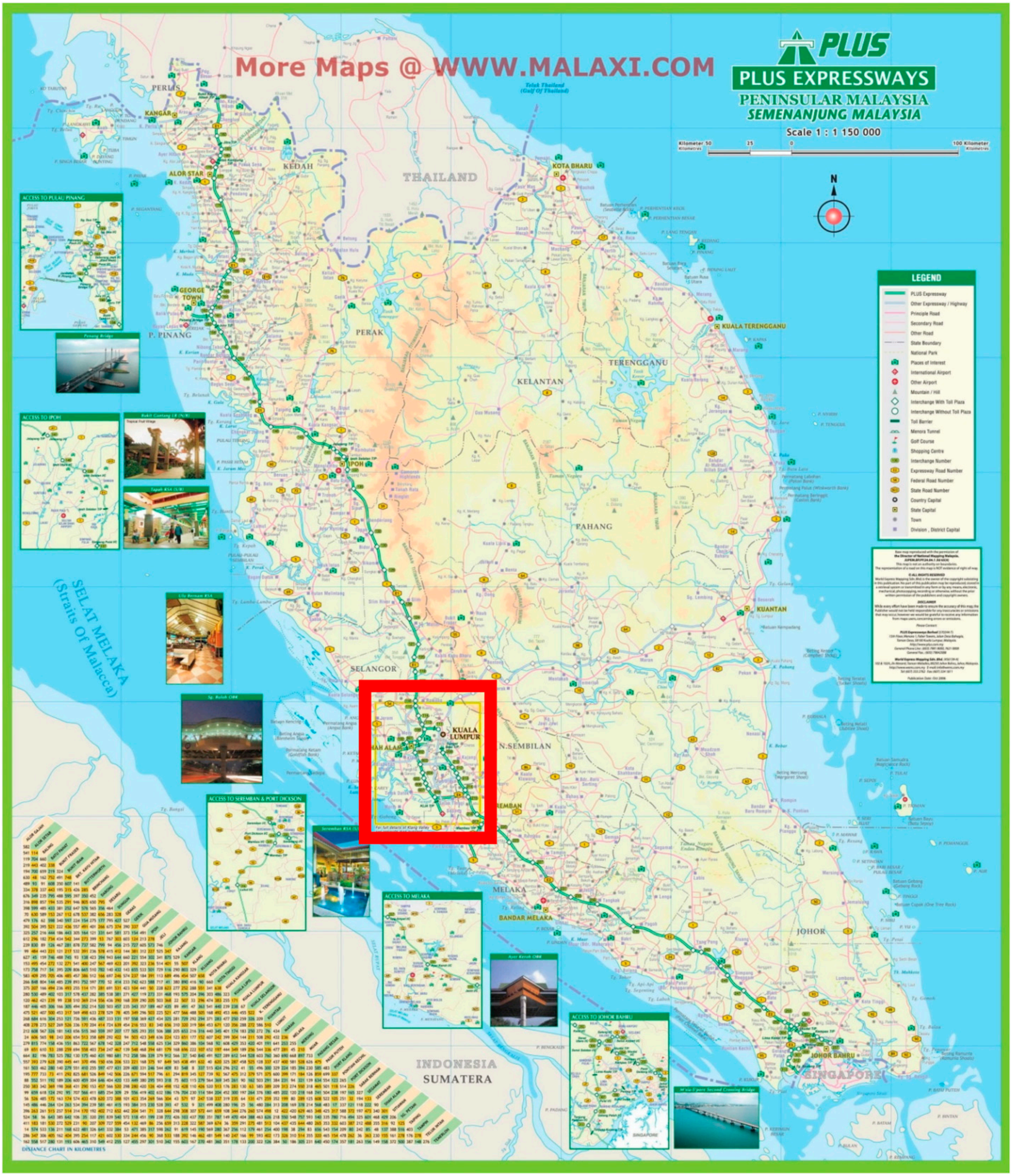


**Fig. 1.** Location of Klang Valley, Malaysia shown in read pane (http://www.malaxi.com/highway_express/images/plus_expressways_map.jpg) (Map copyrighted by World Express Mapping Sdn Bhd, with permission)

the code of practice especially created for low-cost houses, as stated in CIS 1:1998 and CIS 2:1998, which were published by Construction Industry Development Board (CIDB) (Zaid and Graham 2011). Defined in the context of Malaysia, a low-cost house is a living unit with a selling price ranging from Malaysian Ringgit (RM) 25,000 to RM 42,000 based on the value of the developed land. Affordable housing could be a house with terrace, a detached house, or a flat with minimum design specifications of a built-up area between 56 and 70 $m^2$,



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with a living room, a dining area, a kitchen, a bathroom, three bedrooms, and washing and drying areas. Those eligible to own a unit under low-cost housing are those with a monthly household income ranging from RM 750 to RM 1,500. In some cases, houses may be rented out at a low monthly rate. To improve the quality of life, social facilities like religious centers, schools, open spaces, recreational areas, community halls, and libraries are also provided (Government of Malaysia 2010).

Early in 2010, residential property transactions of all types increased in the Klang Valley. The Managing Director of CB Richard Ellis Malaysia asserted that market sentiment in 2010 was more optimistic than in 2009, but cautious optimism was advised. Following a good fourth quarter in 2009, the property market expected the positive sentiment to continue in 2010, witnessing a fresh enthusiasm and high levels of activity. This enthusiasm might be linked to the overall bullish economic sentiment for 2010 because regional investors became increasingly interested in the Malaysian property market (CBRE 2010).

There are a total 100,105 units of low-cost housing in Wilayah Persekutua, Kuala Lumpur, consisting low-cost houses and flats. However, Selangor, with a total of 279,018 affordable housing units, is the state with the highest number of affordable housing units, followed by Johor, with a total of 168,949 units. This means that there are a total of 379,123 units, approximately 37% of which are affordable housing in Klang Valley; more than 70% of housing stock in Klang Valley consists of affordable units, such as terraced houses, low-cost houses, and low-cost flats. Low-cost housing is the second largest type, which makes up 22% of all types of existing houses in Klang Valley. Less than 20% of existing housing units are condos or apartments. The completed affordable housing in Kuala Lumpur is 2,866 units. Pulau Pinang is the state with the highest proportion of affordable housing (18.2%); Kuala Lumpur has the second highest proportion (18.2%), followed by Selangor (10.8%).

## Defects in Housing

Several categories of defects in housing have been previously identified. According to Garrand (2001), defects in buildings and housing can be classified into a number of categories, including defects in foundation and ground floor structures, external walls, roofs, internal walls and floors, above ground services, below ground drainage, and external works (Table 1).

Many researchers and commentators have discussed the various causes of defective work in the construction industry. Based on their discussions and analyses, the causes of defective work can be classified into a smaller number of categories (Table 2).

## Research Procedures and Analysis Methods

A questionnaire survey was utilized in this research. There are two fundamental types of questionnaire design: open-ended and close-ended (Lodico et al. 2010; Peterson 1944). In this research, close-ended questions were used to seek the most frequent types of defects that occurred in affordable housing in Klang Valley, Malaysia. In addition, there are two types of self-administration procedures for questionnaires: (1) self-administration in the presence of the researcher, and (2) self-administered questionnaires without the presence of the researcher. Self-administered questionnaires in the presence of the researcher were used during this research project because it allowed queries or uncertainties to be addressed immediately, and it typically ensures a high response rate. The disadvantage of self-administered questionnaires, without the presence of a researcher, is that respondents may misunderstand or have difficulties understanding the questions, which leads to inaccurate answers or no answers. The researchers felt that this was a particular risk, particularly for those respondents who lived in the affordable housing areas and did not have any formal education, because many of them are senior citizens.

There were 310 participants involved in the research who lived in affordable housing residences in the Klang Valley. Because this questionnaire survey was self-administrated in the presence of the researcher, all these 310 respondents completed their forms assisted by the researcher. Questionnaires were distributed in the following areas in Klang Valley: PPR Kerinchi, Taman Bukit Angkasa, Taman Desa Ria, PPR Kampung Baru Air Panas, and Taman Putra Damai, in 2011, after a pilot study. The sample size is similar to a study by Omar (2008), the aim of which was to interpret the natural communal living environment in Malaysian affordable housing. The selected affordable housing areas were suggested by the Ministry of Housing and Local Government; therefore, the details have a high extent of reliability. Data analysis was conducted using the following tests: (1) Cronbach's alpha, (2) frequency analysis, (3) one sample *t*-test, (4) scale index analysis, (5) correlation, and (6) partial correlation.

The numbers of respondents from each affordable housing area (Table 3) and the overall profile of the respondents (Table 4) were also recorded. A higher proportion of respondents were owners of their housing unit. Most respondents were women and were older than 31 years of age; the highest numbers of respondents were older than 50 years of age. This might be because the distribution of questionnaires took place during weekday working hours; many middle-aged respondents would have been at work and unable to respond.

A significant proportion of respondents had lived in their housing units for 4–6 years. This is because residents from Taman Desa Ria and PPR Kampung Baru Air Panas, which are two of the affordable housing areas where the questionnaires were distributed, only started to move into the area approximately 6 years before the research began; 31.6% had residency lengths of more than 10 years, 29% had habitation periods of 1–3 years, and 2.9% had a length of residency of 7–10 years. Sixty percent of residents had completed secondary education; 27.4% of respondents had the highest level of education at the primary school level; and only 9.4% of respondents had tertiary education.

Approximately 44% of respondents had a monthly family income between RM 1,001 and RM 1,500. Although 27 (8.9%) of the participants had a monthly family income level of less than RM 500, 107 (35.3%) of respondents had a monthly family income level between RM 500 and RM 1,000, and 36 (11.9%) respondents had a monthly family income level more than RM 1,500. However, approximately 2.3% of respondents refused to provide their monthly family income level, possibly to protect their privacy.

## Analysis Interpretation and Results

### *Reliability Test*

The overall Cronbach's alpha coefficient for a total of 25 variables is 0.855 (Table 5), which is also an acceptable reliability of Cronbach's coefficient (Nunnally 1978). This is a method to test the internal consistent score of one variable with composite scores from the remaining variables. According to De Vaus (2004), variables with corrected item–total correlation value less than 0.30 should be removed. Because all of the corrected item–total correlation values exceeded 0.30, no variables were removed. Further, the last column in Table 5 displays Cronbach's alpha if the item was deleted with the



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**Table 1.** Summary on Types of Building Defects

| Type of defects | Authors |
|---|---|
| Foundation and floor structure | |
| Distortion and cracking of ground floors | Olubodun and Mole (1999); Georgiou et al. (1999); Olubodun (2000); Garrand (2001); Ilozor et al. (2004); Lourenco et al. (2006); Georgiou (2010) |
| External walls | |
| Cracking in external wall | Olubodun and Mole (1999); Georgiou et al. (1999); Olubodun (2000); Garrand (2001); Ilozor et al. (2004); Kazaz and Birgonul (2005); Lourenco et al. (2006); Georgiou (2010) |
| Internal staining; mold growth and fungal decay | Garrand (2001); Chew (2005); Lourenco et al. (2006) |
| Roof | |
| Water staining, mold growth and fungal decay | Ilozor et al. (2004); Garrand (2001); Chew (2005) |
| Deterioration of coverings | Olubodun and Mole (1999); Olubodun (2000); Garrand (2001); Ilozor et al. (2004); Lourenco et al. (2006) |
| Deformation or displacement of roof | Olubodun and Mole (1999); Olubodun (2000); Garrand (2001); Ilozor et al. (2004) |
| Internal walls and floors | |
| Inadequate resistance to the passage of sound | Watt (1999); Garrand (2001); Olubodun and Mole (1999); Olubodun (2000); Garrand (2001); |
| Distortion and cracking of partition | Ilozor et al. (2004); Kazaz and Birgonul (2005); Lourenco et al. (2006); Georgiou (2010) |
| Above ground service | |
| Failure of water supply system | Garrand (2001); Ilozor et al. (2004); Kazaz and Birgonul (2005); Georgiou (2010) |
| Poor ventilation system | Watt (1999); Garrand (2001) |
| Below ground drainage and external works | |
| Surcharge of drains and flooring | Olubodun and Mole (1999); Olubodun (2000); Garrand (2001); Kazaz and Birgonul (2005); |
| Fracture and displacement of drains | Georgiou (2010) |
| Wall and floor finishes | |
| Uneven floor finishes | Georgiou et al. (1999); Chew (2005) |
| Uneven wall plaster | Georgiou et al. (1999); Kazaz and Birgonul (2005) |
| Broken floor tiles | Kazaz and Birgonul (2005); Chew (2005) |
| Broken wall tiles | Olubodun and Mole (1999); Olubodun (2000); Kazaz and Birgonul (2005); Chew (2005) |
| Damp proof course | |
| Dampness to concrete wall | Watt (1999); Olubodun (2000); Georgiou (2010) |
| Floor dampness | Olubodun and Mole (1999); Olubodun (2000); Georgiou (2010) |
| Door and window fixings | |
| Faulty door knobs | Olubodun (2000); Kazaz and Birgonul (2005) |
| Broken window knobs | Olubodun and Mole (1999); Olubodun (2000); Kazaz and Birgonul (2005) |
| Sanitary installation | |
| Faulty sanitary installation | Kazaz and Birgonul (2005) |
| Electrical installation | |
| Exposed wires | Georgiou et al. (1999) |
| Faulty electrical fittings | Olubodun and Mole (1999); Georgiou et al. (1999); Olubodun (2000); Ilozor et al. (2004); Kazaz and Birgonul (2005) |
| Piping work | |
| Leakage of pipe | Olubodun and Mole (1999); Georgiou et al. (1999); Olubodun (2000) |

purpose of determining if the variable contributed to the overall alpha value. The removal of any one variable only caused minor differences to the overall Cronbach's alpha; therefore, all variables were retained.

### *Most Common Defects in Affordable Housing*

Respondents were required to determine how frequently the listed defects occurred in their units according to the scales provided, to identify the type of defect that most frequently occurred in low-cost housing. The frequency for each type of defect, including their corresponding percentage, mean, SD, and rank, are listed in Table 6. A total of 25 defects are ranked from 1 to 25.

The most frequently occurring defect was leaking pipes (mean value, 2.59); approximately 16.1% of respondents acknowledged that this defect was frequently a problem in their housing area. This included both the piping internal to the unit in addition to the external piping system. The second most common defect reported by respondents was the total failure of the water supply system (mean value, 2.48, slightly lower than for leaking pipes); 9.4% of participants claimed that the water supply to their housing unit failed frequently.

Cracks in the external walls had the third highest mean value (2.31), and 24.2% of residents reported that this defect occurred frequently. Moreover, this defect also has the highest SD (1.21) of all the defects, representing significant volatility of opinion among respondents. Other significant defects included faulty door knobs (mean 2.25) and concrete wall dampness (mean 1.94). These four defects had similar mean values, making these defects the most frequently observed defects in the construction of affordable housing in Klang Valley.

### *One Sample t-Test*

One sample $t$-tests were utilized to identify whether the various defects occurred in affordable housing in Klang Valley. Because the scale of defect of a never occur is 1 and a scale of defect of rarely occur is 2, the test value is set at 1.5 for occurrence of defects in low-cost housing.



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**Table 2.** Summary of Causes of Defects

| Causes | Authors |
|---|---|
| Design | Olubodun and Mole (1999); Olubodun (2000); Pheng and Wee (2001); Chew (2005); Karim et al. (2006) |
| Aging | Olubodun (2000); Chew (2005) |
| Construction | Olubodun and Mole (1999); Chew (2005) |
| Vandalism | Olubodun (2000) |
| Changing standard | Olubodun and Mole (1999); Olubodun (2000) |
| Client | Chan et al. (2006) |
| User involvement | Hammarlund and Josephson (1991) |
| Time pressure | Pheng and Wee (2001); Hammarlund and Josephson (1991) |
| Cost pressure | Pheng and Wee (2001) |
| Workers problem | Hammarlund and Josephson (1991) |
| External influence | Olubodun (2000) |
| Tenant's lack of care | Olubodun (2000) |
| Material selection | Pheng and Wee (2001); Chew (2005); Karim et al. (2006) |
| Poor site investigation | Pheng and Wee (2001) |
| Management | Hammarlund and Josephson (1991); Chan et al. (2006) |
| Workmanship | Chew (2005); Chan et al. (2006); Karim et al. (2006); Hall and Tomkins (2001) |
| Lack of quality | Chan et al. (2006) |

**Table 3.** Regional Distribution of Respondents

| Low-cost housing area | Number of questionnaires distributed | (%) |
|---|---|---|
| PPR Kerinchi | 72 | 23.2 |
| Taman Bukit Angkasa | 50 | 16.1 |
| Taman Desa Ria | 65 | 21.0 |
| PPR Kampung Baru Air Panas | 60 | 19.4 |
| Taman Putra Damai | 63 | 20.3 |
| Total | 310 | 100.0 |

The test value is set at 1.5 instead of 4 (which is the value for the frequently occurring defects), because a house with this value would be considered an unsafe living space. Hence, this test examines defects that exist in low-cost housing and identifies the most frequently occurring defects. The hypotheses are shown as follows:

$H_0$: $\mu = 1$ (These hypotheses represent that the defect has never occurred in low-cost housing)

$H_A$: $\mu \geq 1$ (These hypotheses represent that the defect has occurred in low-cost housing)

The output of the one sample $t$-test is displayed in Table 7. The second column of the table represents the $t$ statistical value obtained, and the third column is the $P$ value of the test. To interpret the results of the one sample $t$-test, each of the variables are compared with a two-tailed critical $t$ value of $\pm 1.965$, which is obtained with a significance of 0.05 at the 95% confidence level. Most of the defects were statistically significant (Table 7), except for distortion and cracking of the ground floor ($t = -0.519$), poor ventilation system ($t = -1.33$), uneven floor finishes ($t = 0.817$), uneven wall plaster ($t = 0.314$), broken floor tiles ($t = -0.73$), and broken wall tile ($t = -1.921$). The null hypothesis, $H_0$, $\mu = 1$, was rejected for 19 defects that had significant levels less than 0.05.

### *Categories for Each Type of Defect*

A scale index can be created using the mean value for each type of defect, based on the maximum and minimum mean values from the total of 25 defects. Each defect is classified by frequency of occurrence, using four scales: never, rarely, frequent, or very frequent. The formula for the scale index is shown in Eq. (1)

**Table 4.** Respondents' Profiles

| Sociodemographic characteristics | Frequency ($n$ = 310) | (%) |
|---|---|---|
| Ownership | | |
| Owner | 168 | 54.2 |
| Tenant | 142 | 45.8 |
| Gender | | |
| Male | 129 | 41.6 |
| Female | 181 | 58.4 |
| Age, years | | |
| 18–25 | 28 | 9.0 |
| 26–30 | 41 | 13.2 |
| 31–40 | 63 | 20.3 |
| 41–50 | 80 | 25.8 |
| Older than 50 | 98 | 31.6 |
| Length of residency | | |
| Less than 12 months | 4 | 1.3 |
| 1–3 years | 90 | 29.0 |
| 4–6 years | 109 | 35.2 |
| 7–10 years | 9 | 2.9 |
| More than 10 years | 98 | 31.6 |
| Education level | | |
| No formal education | 10 | 3.2 |
| Primary | 85 | 27.4 |
| Secondary | 186 | 60.0 |
| Tertiary | 29 | 9.4 |
| Monthly family income level | | |
| Less than RM500 | 27 | 8.7 |
| RM500–RM1,000 | 107 | 34.5 |
| RM1001–RM1,500 | 133 | 42.9 |
| More than RM1,500 | 36 | 11.6 |
| Missing | 7 | 2.3 |

Average scale deviation,

$$x = (\text{maximum mean-minimum mean}) / \text{number of scale} \quad (1)$$

Knowing the value of average scale deviation, the degree of frequency for never, rarely, frequent, and very frequent are illustrated in Eqs. (2)–(5), respectively





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**Table 5.** Statistical Result for Reliability Analysis

| Type of defects | Scale mean if item deleted | Scale variance if item deleted | Corrected item-total correlation | Cronbach's alpha if item deleted |
|---|---|---|---|---|
| Distortion and cracking of ground floor | 39.5355 | 67.693 | 0.460 | 0.849 |
| Cracking in external wall | 38.7065 | 63.386 | 0.474 | 0.849 |
| Internal staining, mold growth, and fungal decay on external wall | 39.3774 | 66.372 | 0.505 | 0.847 |
| Water staining, mold growth, and decay on roof | 39.7645 | 68.459 | 0.498 | 0.848 |
| Deterioration of roof covering | 39.8355 | 69.206 | 0.496 | 0.849 |
| Deformation and displacement of roof | 39.8032 | 69.667 | 0.457 | 0.850 |
| Inadequate resistance to the passage of sound | 39.3419 | 65.061 | 0.586 | 0.844 |
| Distortion and cracking of partition | 39.2613 | 65.805 | 0.604 | 0.844 |
| Total failure of water supply system | 38.5387 | 66.793 | 0.426 | 0.849 |
| Poor ventilation system | 39.5645 | 67.334 | 0.509 | 0.847 |
| Surcharge of drains and flooring | 39.8548 | 69.950 | 0.235 | 0.855 |
| Fracture and displacement of drains | 39.7097 | 68.466 | 0.513 | 0.848 |
| Uneven floor finishes | 39.4839 | 67.254 | 0.470 | 0.848 |
| Uneven wall plaster | 39.5032 | 67.681 | 0.411 | 0.850 |
| Broken floor tiles | 39.5194 | 67.849 | 0.364 | 0.852 |
| Broken wall tiles | 39.5935 | 66.753 | 0.504 | 0.847 |
| Concrete wall dampness | 39.0742 | 65.480 | 0.476 | 0.848 |
| Faulty door knobs | 38.7645 | 70.964 | 0.104 | 0.861 |
| Broken window knobs | 39.2710 | 67.700 | 0.473 | 0.848 |
| Faulty sanitary installation | 39.3935 | 68.078 | 0.432 | 0.849 |
| Exposed wires | 39.6290 | 68.590 | 0.349 | 0.852 |
| Faulty electrical fitting | 39.4355 | 65.567 | 0.612 | 0.843 |
| Pipe leakage | 38.4226 | 66.077 | 0.422 | 0.850 |
| Floor dampness | 39.6000 | 72.759 | −0.010 | 0.863 |
| Leakage of water tank | 39.4032 | 71.361 | 0.088 | 0.861 |

$$\text{Index scale for never} = \text{minimum mean} + x = x_1 + x = x_2 \quad (\text{degree of frequency for never} = x - x_2) \tag{2}$$

$$\text{Index scale for rarely} = x_2 + x = x_3 \quad (\text{degree of frequency for rarely} = x_2 - x_3) \tag{3}$$

$$\text{Index scale for frequent} = x_3 + x = x_4 \quad (\text{degree of frequency for rarely} > x_3 - x_4) \tag{4}$$

$$\text{Index scale for very frequent} = x_4 + x = x_5 \quad (\text{degree of frequency for rarely} > x_4 - x_5) \tag{5}$$

The defects were rearranged according to their scale and categorized by frequency. The type of defect, with frequency and number, and percentage of defects for each category of frequency of occurrence are depicted in Tables 8 and 9, respectively.

Twelve (48%) types of defects almost never occurred in Klang Valley, and this categorization of infrequent occurrence contained the greatest proportion of defects, with mean values ranging from 1.16 to 1.52. These defects included all those related to the roof (water staining, mold growth and decay on roof, deterioration of roof covering, and deformation and displacement of the roof) and the below ground drainage and external wall defects. This indicates the roofing and below ground drainage were less problem prone than other elements of construction in affordable housing in Klang Valley. Eight types of defects (32%) were considered to occur rarely, with mean values ranging from 1.52 to 1.88. These included internal staining, mold growth and fungal decay on external walls, inadequate resistance to the passage of sound, distortion and cracking of partitions, uneven floor finishes, broken window knobs, faulty sanitary installation, faulty electrical fitting, and leakage of water tank. The number of rarely occurring defects were second only to the number of never occurring defects, and consisted primarily of defective problems related to internal walls and flooring. Cracking in external walls, total failure of the water system, faulty doors and knobs, and leakage of pipes were all considered to occur very frequently. Interestingly, only one defect, concrete wall dampness, was considered to occur frequently.

### Correlation between Types of Defects

The presence of correlations between types of defects may present opportunities for rapid improvements in construction techniques. The correlation matrix between the most common defects found in low-cost housing is presented in Table 10. Positive coefficients indicate that both defects tend to be present; negative coefficients indicate that when one defect is present, the other tends to be absent.

Three defects (cracking in external walls, concrete wall dampness, and leaking pipes) were all significantly correlated. There was a strong relationship between cracking in external walls and concrete wall dampness ($r = 0.575$; the correlation was significant at the 1% level). This might happen because water was able to penetrate between the cracks in the wall and cause dampness in concrete walls. There was also a strong correlation between concrete wall dampness and the leaking pipes ($r = 0.535$, significant at the 1% level). This



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**Table 6.** Defects in Low-Cost Housing

| Type of defect | Never Frequency | Never (%) | Rarely Frequency | Rarely (%) | Frequent Frequency | Frequent (%) | Very frequent Frequency | Very frequent (%) | Mean | SD | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Foundation and floor structure | | | | | | | | | | | |
| Distortion and cracking of ground floor | 185 | 59.68 | 105 | 33.87 | 16 | 5.16 | 4 | 1.29 | 1.48 | 0.66 | 16 |
| External wall | | | | | | | | | | | |
| Cracking in external wall | 86 | 27.74 | 117 | 37.74 | 32 | 10.32 | 75 | 24.19 | 2.31 | 1.12 | 3 |
| Internal staining, mold growth, and fungal decay on external wall | 159 | 51.29 | 108 | 34.84 | 39 | 12.58 | 4 | 1.29 | 1.64 | 0.75 | 9 |
| Roof | | | | | | | | | | | |
| Water staining, mold growth, and decay on roof | 246 | 79.35 | 50 | 16.13 | 14 | 4.52 | 0 | 0.00 | 1.25 | 0.53 | 22 |
| Deterioration of roof covering | 262 | 84.51 | 40 | 12.90 | 8 | 2.58 | 0 | 0.00 | 1.18 | 0.45 | 24 |
| Deformation and displacement of roof | 246 | 79.35 | 62 | 20.0 | 2 | 0.65 | 0 | 0.00 | 1.21 | 0.43 | 23 |
| Internal wall and floor | | | | | | | | | | | |
| Inadequate resistance to the passage of sound | 155 | 50.00 | 108 | 34.83 | 40 | 12.90 | 7 | 2.26 | 1.67 | 0.78 | 8 |
| Distortion and cracking of partition | 120 | 38.71 | 148 | 47.74 | 40 | 12.90 | 2 | 0.65 | 1.75 | 0.70 | 6 |
| Above ground service | | | | | | | | | | | |
| Total failure of water supply system | 34 | 10.97 | 123 | 39.68 | 124 | 40.0 | 29 | 9.35 | 2.48 | 0.81 | 2 |
| Poor ventilation system | 193 | 62.26 | 96 | 30.97 | 19 | 6.13 | 2 | 0.65 | 1.45 | 0.64 | 17 |
| Below ground drainage and external wall | | | | | | | | | | | |
| Surcharge of drains and flooring | 275 | 88.70 | 31 | 10.00 | 3 | 0.97 | 1 | 0.32 | 1.16 | 0.68 | 25 |
| Fracture and displacement of drains | 223 | 71.94 | 79 | 25.48 | 8 | 2.58 | 0 | 0.00 | 1.30 | 0.51 | 21 |
| Wall and floor finishes | | | | | | | | | | | |
| Uneven floor finishes | 178 | 57.42 | 102 | 32.90 | 27 | 8.71 | 3 | 0.98 | 1.53 | 0.69 | 13 |
| Uneven wall plaster | 186 | 60.00 | 96 | 30.97 | 21 | 6.77 | 7 | 2.26 | 1.51 | 0.72 | 14 |
| Broken floor tiles | 201 | 64.84 | 73 | 23.54 | 27 | 8.71 | 9 | 2.90 | 1.50 | 0.77 | 15 |
| Broken wall tiles | 212 | 68.39 | 72 | 23.23 | 19 | 6.13 | 7 | 2.26 | 1.42 | 0.71 | 18 |
| Damp proof course | | | | | | | | | | | |
| Dampness to concrete wall | 110 | 35.48 | 129 | 41.61 | 50 | 16.13 | 21 | 6.77 | 1.94 | 0.89 | 5 |
| Dampness to floor | 210 | 67.74 | 75 | 24.19 | 21 | 6.77 | 4 | 1.29 | 1.42 | 0.68 | 19 |
| Door and window fixings | | | | | | | | | | | |
| Faulty door knobs | 49 | 15.81 | 162 | 52.26 | 71 | 22.90 | 28 | 9.03 | 2.25 | 0.83 | 4 |
| Broken window knobs | 113 | 36.45 | 163 | 52.58 | 34 | 10.97 | 0 | 0.00 | 1.75 | 0.64 | 7 |
| Sanitary installation | | | | | | | | | | | |
| Faulty sanitary installation | 144 | 46.45 | 140 | 45.16 | 25 | 8.06 | 1 | 0.32 | 1.62 | 0.65 | 10 |
| Electrical installation | | | | | | | | | | | |
| Exposed wires | 222 | 71.61 | 62 | 20.00 | 20 | 6.45 | 6 | 1.94 | 1.39 | 0.70 | 20 |
| Faulty electrical fitting | 166 | 53.55 | 112 | 36.13 | 28 | 9.03 | 4 | 1.29 | 1.58 | 0.71 | 12 |
| Piping work | | | | | | | | | | | |
| Leakage of pipe | 39 | 12.58 | 98 | 31.61 | 123 | 39.68 | 50 | 16.13 | 2.59 | 0.90 | 1 |
| Leakage of water tank | 169 | 54.52 | 98 | 31.61 | 37 | 11.94 | 6 | 1.94 | 1.61 | 0.77 | 11 |

was probably caused by water from the leaking pipes collecting and consequently dampening the concrete walls. Leaking pipes were moderately correlated with cracking in external walls ($r = 0.412$, significant at the 1% level). These three defects were correlated and might be caused jointly because the piping systems might be laid in concrete walls. When a concrete wall cracks, or there is movement in the wall, the pipe laid in the wall might break, causing release of water. The, total failure of water supply systems was weakly correlated with cracking in external walls, concrete walls dampness, and faulty door knobs.

## *Partial Correlation Matrix of Variables Controlling for Total Failure*

Correlation tests only identify correlation between two variables; therefore, partial correlation was used to further analyze relationships between greater numbers of variables. Partial correlation analysis is used to determine the relationship among three defects, by controlling a particular defect; it identifies the unique variance between two defects by eliminating the variance from a third defect.

### Partial Correlation Matrix of the Variables, Controlling for Cracking in an External Wall

By removing the variation associated with cracking in external walls, as shown in Table 11, the results of correlation between two defects are compared with the correlation output in Table 10. The correlation coefficients between concrete wall dampness and leaking pipes decreases to $r = 0.401$, while remaining significant at the 1% level. This indicates that the correlation between these other defects is affected by the cracking of external walls. Careful construction of the external walls should therefore prevent leaking pipes and dampness in the concrete wall from occurring. Correlations between other defects were not affected greatly by controlling for the cracking in the external wall defect.

### Partial Correlation Matrix of the Variables, Controlling for Total Failure of Water Supply System

Table 12 presents the partial correlation of the variables when controlling for the total failure of water supply systems. The correlation between concrete walls dampness and cracking in external



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**Table 7.** One-Sample *t*-Test

| Type of defects | Test value = 1.5; degree of frequency = 309 | | | | | |
|---|---|---|---|---|---|---|
| | | | | 95% Confidence interval of the difference | | |
| | *t* | Significance (2-tailed) | Mean difference | Lower | Upper | Significance |
| Distortion and cracking of ground floor | –0.519 | 0.604 | –0.01935 | –0.0928 | 0.0541 | Not significant |
| Cracking in external wall | 12.718 | 0.000 | 0.80968 | 0.6844 | 0.9350 | Significant |
| Internal staining, mold growth, and fungal decay on external wall | 3.259 | 0.001 | 0.13871 | 0.0550 | 0.2225 | Significant |
| Water staining, mold growth, and decay on roof | −8.272 | 0.000 | –0.24839 | –0.3075 | –0.1893 | Significant |
| Deterioration of roof covering | −12.564 | 0.000 | –0.31935 | –0.3694 | –0.2693 | Significant |
| Deformation and displacement of roof | −11.879 | 0.000 | –0.28710 | –0.3347 | –0.2395 | Significant |
| Inadequate resistance to the passage of sound | 3.910 | 0.000 | 0.17419 | 0.0865 | 0.2618 | Significant |
| Distortion and cracking of partition | 6.454 | 0.000 | 0.25484 | 0.1771 | 0.3325 | Significant |
| Total failure of water supply system | 21.214 | 0.000 | 0.97742 | 0.8868 | 1.0681 | Significant |
| Poor ventilation system | −1.330 | 0.184 | –0.04839 | –0.1200 | 0.0232 | Not significant |
| Surcharge of drains and flooring | −8.738 | 0.000 | –0.33871 | –0.4150 | –0.2624 | Significant |
| Fracture and displacement of drains | −6.620 | 0.000 | –0.19355 | –0.2511 | –0.1360 | Significant |
| Uneven floor finishes | 0.817 | 0.414 | 0.03226 | –0.0454 | 0.1099 | Not significant |
| Uneven wall plaster | 0.314 | 0.754 | 0.01290 | –0.0679 | 0.0937 | Not significant |
| Broken floor tiles | –0.073 | 0.942 | –0.00323 | –0.0898 | 0.0834 | Not significant |
| Broken wall tiles | −1.921 | 0.056 | –0.07742 | –0.1567 | 0.0019 | Not significant |
| Dampness to concrete wall | 8.775 | 0.000 | 0.44194 | 0.3428 | 0.5410 | Significant |
| Faulty door knobs | 15.963 | 0.000 | 0.75161 | 0.6590 | 0.8443 | Significant |
| Broken window knobs | 6.737 | 0.000 | 0.24516 | 0.1736 | 0.3168 | Significant |
| Faulty sanitary installation | 3.342 | 0.001 | 0.12258 | 0.0504 | 0.1947 | Significant |
| Exposed wires | −2.857 | 0.005 | –0.11290 | –0.1907 | –0.0352 | Significant |
| Faulty electrical fitting | 2.002 | 0.046 | 0.08065 | 0.0014 | 0.1599 | Significant |
| Leakage of pipe | 21.287 | 0.000 | 1.09355 | 0.9925 | 1.1946 | Significant |
| Dampness to floor | −2.184 | 0.030 | –0.08387 | –0.1594 | –0.0083 | Significant |
| Leakage of water tank | 2.579 | 0.010 | 0.11290 | 0.0268 | 0.1990 | Significant |

walls ($r = 0.563$), and the correlation between leaking pipes and concrete wall dampness ($r = 0.524$), both remained high and significant at the 1% level. This indicated that relationships between the pairs of defects remained strong, irrespective of the failure of water supply systems.

### Partial Correlation Matrix of the Variables, Controlling for Concrete Wall Dampness

Generally, all the coefficient values for all of the variables decreased when concrete wall dampness was controlled for (Table 13); this defect was significantly associated with other defects. Therefore, many other defects could be prevented by properly constructing damp-proofed concrete walls. The correlation coefficient between cracking in external walls and leaking pipes ($r = 0.151$, significant at the 1% level) was less strong than it would have been if the concrete wall dampness was not controlled for ($r = 0.412$); the coefficient decreased by 0.261. In other words, the correlation between these defects was influenced by concrete wall dampness.

### Partial Correlation Matrix of the Variables, Controlling for Faulty Door Knobs

The correlations between defects were not markedly affected by controlling for faulty door knobs (Table 14), indicating that some coefficients increased, whereas others decreased. This means that defective door knobs had little effect on other defects.

### Partial Correlation Matrix of Variables, Controlling for Leaking Pipes

There was a clear correlation between cracking in external walls and concrete wall dampness (Table 15), where the relationship decreased from a strong ($r = 0.575$) to moderate ($r = 0.460$) relationship when the leaking pipes were controlled for, which still remained significant at the 1% level. This result might occur, because without leaking pipes inside the concrete walls, there would be no water flow through cracks in external walls, and therefore, the dampness to the concrete would decrease. In other words, the defects of cracking in external walls and concrete wall dampness would be strongly reduced through careful and proper installation of piping systems.

## Discussion on Findings

With the increase in demand for housing, mainly because of high urbanization rates, there is an emphasis on the development of affordable housing solutions by the Malaysian Federal Government. Apart from providing adequate housing for low-income groups, the housing policy also emphasizes the significance of comprehensive settlement planning to achieve safe and decent living conditions. This is in line with the Eighth, Ninth, and Tenth Malaysian Plans, which have the objective of increasing the quality of affordable new and existing homes. This research found that most participants identified defects that were similar to those identified through the literature review. Results from the questionnaire showed that the most common defect that occurred in affordable housing was

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**Table 8.** Type of Defects with Respective Degree of Frequency

| Type of defect | Mean | Degree of frequency |
|---|---|---|
| Foundation and floor structure | | |
| Distortion and cracking of ground floor | 1.48 | Never |
| External wall | | |
| Cracking in external wall | 2.31 | Very frequent |
| Internal staining, mold growth and fungal decay on external wall | 1.64 | Rarely |
| Roof | | |
| Water staining, mold growth and decay on roof | 1.25 | Never |
| Deterioration of roof covering | 1.18 | Never |
| Deformation and displacement of roof | 1.21 | Never |
| Internal wall and floor | | |
| Inadequate resistance to the passage of sound | 1.67 | Rarely |
| Distortion and cracking of partition | 1.75 | Rarely |
| Above ground service | | |
| Total failure of water supply system | 2.48 | Very frequent |
| Poor ventilation system | 1.45 | Never |
| Below ground drainage and external wall | | |
| Surcharge of drains and flooring | 1.16 | Never |
| Fracture and displacement of drains | 1.30 | Never |
| Wall and floor finishes | | |
| Uneven floor finishes | 1.53 | Rarely |
| Uneven wall plaster | 1.51 | Never |
| Broken floor tiles | 1.50 | Never |
| Broken wall tiles | 1.42 | Never |
| Damp proof course | | |
| Dampness to concrete wall | 1.94 | Frequent |
| Dampness to floor | 1.42 | Never |
| Door and window fixings | | |
| Faulty door knobs | 2.25 | Very frequent |
| Broken window knobs | 1.75 | Rarely |
| Sanitary installation | | |
| Faulty sanitary installation | 1.62 | Rarely |
| Electrical installation | | |
| Exposed wires | 1.39 | Never |
| Faulty electrical fitting | 1.58 | Rarely |
| Piping work | | |
| Leakage of pipe | 2.59 | Very frequent |
| Leakage of water tank | 1.61 | Rarely |

**Table 9.** Number and Percentage of Defects for Each Degree of Frequency

| Degree of frequency | Number of defect | (%) |
|---|---|---|
| Never | 12 | 48.00 |
| Rarely | 8 | 32.00 |
| Frequent | 1 | 4.00 |
| Very frequent | 4 | 16.00 |

leaking pipes. Approximate 17% of low-cost housing residents admitted that pipe leakage always happened in their housing unit, and about 40% reported that pipe leakage was a frequent problem. Another significant problem was the total failure of the water supply system. This defect created many inconveniences to residents; without a water supply, many core household activities were simply not possible. Cracking in walls was a commonly occurring defect that happened in almost all housing units, whether they were low-, medium-, or high-cost housing. It is undeniable that cracking in external walls is another common defect in affordable housing. Although cracks were the third most frequently occurring defect in affordable housing, 75% of respondents revealed that this defect happened very frequently in their housing unit, indicating that cracking of walls is a widely spread problem, whereas the leaking pipes and water supply problems might be isolated to a smaller number of construction projects. Another two frequently occurring defects were concrete wall dampness and faulty door knobs. Although these five defects were considered to be the most frequent defects in low-cost housing, concrete wall dampness was found to be a frequent defect, whereas the other defects were considered to be very frequent occurrences. Thus, from the findings of questionnaire survey, it was proven that residents of affordable housing face quality problems in their units

There were also significant correlations among the top five most frequent defects. Moderate or strong correlations existed among the defects of cracks in external walls, leaking pipes, and concrete wall dampness. This indicated that when one of the defects existed, it was likely that the others occurred simultaneously. This indicated that one of the defects was causing the other two, or that there was a fourth, unseen, influence that was possibly causing all three defects. It seems likely, however, that properly constructed external walls might prevent cracking of concrete walls and might prevent the other defects from occurring, particularly leaking pipes.

The respondents were from five different areas of affordable housing located in Klang Valley, Malaysia, two of which were



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**Table 10.** Correlations Matrix of the Variables

| Variables | Cracking in external wall | Total failure of water supply system | Concrete wall dampness | Faulty door knobs | Leakage of pipe |
|---|---|---|---|---|---|
| Cracking in external wall | | | | | |
| Pearson's correlation | 1 | | | | |
| Significance (2-tailed) | | Weak | Strong | No Relationship | Moderate |
| Number | 310 | | | | |
| Total failure of water supply system | | | | | |
| Pearson's correlation | 0.243[a] | 1 | | | |
| Significance (2-tailed) | 0.000 | | Weak | Weak | Weak |
| Number | 310 | 310 | | | |
| Concrete wall dampness | | | | | |
| Pearson's correlation | 0.575[a] | 0.142[b] | 1 | | |
| Significance (2-tailed) | 0.000 | 0.012 | | No Relationship | Strong |
| Number | 310 | 310 | 310 | | |
| Faulty door knobs | | | | | |
| Pearson's correlation | –0.011 | 0.158[a] | 0.033 | 1 | |
| Significance (2-tailed) | 0.847 | 0.005 | 0.561 | | No Relationship |
| Number | 310 | 310 | 310 | 310 | |
| Leakage of pipe | | | | | |
| Pearson's correlation | 0.412[a] | 0.182[a] | 0.535[a] | 0.016 | 1 |
| Significance (2-tailed) | 0.000 | 0.001 | 0.000 | 0.779 | |
| Number | 310 | 310 | 310 | 310 | 310 |

[a]Correlation is significant at the 0.01 level (2-tailed).
[b]Correlation is significant at the 0.05 level (2-tailed).

**Table 11.** Partial Correlation Matrix of the Variables, Controlling for Total Failure of Water Supply System

| Control variables | Cracking in external wall | Concrete wall dampness | Faulty door knobs | Leakage of pipe |
|---|---|---|---|---|
| Cracking in external wall | | | | |
| Correlation | 1.000 | 0.563 | –0.051 | 0.386 |
| Significance (2-tailed) | — | 0.000 | 0.368 | 0.000 |
| Degree of frequency | 0 | 307 | 307 | 307 |
| Concrete wall dampness | | | | |
| Correlation | 0.563 | 1.000 | 0.011 | 0.524 |
| Significance (2-tailed) | 0.000 | — | 0.848 | 0.000 |
| Degree of frequency | 307 | 0 | 307 | 307 |
| Faulty door knobs | | | | |
| Correlation | –0.051 | 0.011 | 1.000 | –0.013 |
| Significance (2-tailed) | 0.368 | 0.848 | — | 0.820 |
| Degree of frequency | 307 | 307 | 0 | 307 |
| Leakage of pipe | | | | |
| Correlation | 0.386 | 0.524 | –0.013 | 1.000 |
| Significance (2-tailed) | 0.000 | 0.000 | 0.820 | — |
| Degree of frequency | 307 | 307 | 307 | 0 |

constructed under the People's Housing Programme affordable housing project. Some of the residences were completed approximately 10 years ago, whereas some were completed less than 5 years ago. Residents from various affordable housing programs, covering different periods of habitation, were chosen as respondents, because the research aimed to collect adequate information to provide an overview of the problems with construction in Klang Valley, Malaysia.

Several crucial factors have been identified that may improve the quality of affordable housing. The first factor is to increase the ceiling, or selling price, of low-cost housing, or to secure larger government subsidies. This is considered to be the main factor because all other factors are related to this one. Because construction cost pressures are driven largely by a low ceiling price, many developers may have opted for low-quality materials and employed unskilled labor to undertake work, which reduced their costs. Another cost-related issue is the land value in Klang Valley, which is higher than many other Malaysian states; this caused otherwise identical low-cost developments to be a higher cost than in other states. Therefore, an increase in the ceiling price, improved government subsidies, or the presence of a greater weighting of subsidies for areas like Klang Valley, with higher land costs, may improve the overall quality of affordable housing. Other efforts should be directed toward securing high-quality materials or ensuring a steady supply of skilled laborers to support the construction industry.



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**Table 12.** Partial Correlation Matrix of the Variables, Controlling for Total Failure of Water Supply System

| Control variables | Cracking in external wall | Concrete wall dampness | Faulty door knobs | Leakage of pipe |
|---|---|---|---|---|
| Total failure of water supply system | | | | |
| Correlation | 1.000 | 0.003 | 0.165 | 0.092 |
| Significance (2-tailed) | — | 0.953 | 0.004 | 0.105 |
| Degree of frequency | 0 | 307 | 307 | 307 |
| Concrete wall dampness | | | | |
| Correlation | 0.003 | 1.000 | 0.048 | 0.401 |
| Significance (2-tailed) | 0.953 | — | 0.398 | 0.000 |
| Degree of frequency | 307 | 0 | 307 | 307 |
| Faulty door knobs | | | | |
| Correlation | 0.165 | 0.048 | 1.000 | 0.023 |
| Significance (2-tailed) | 0.004 | 0.398 | — | 0.694 |
| Degree of frequency | 307 | 307 | 0 | 307 |
| Leakage of pipe | | | | |
| Correlation | 0.092 | 0.401 | 0.023 | 1.000 |
| Significance (2-tailed) | 0.105 | 0.000 | 0.694 | — |
| Degree of frequency | 307 | 307 | 307 | 0 |

**Table 13.** Partial Correlation Matrix of the Variables, Controlling for Concrete Wall Dampness

| Control variables | Cracking in external wall | Total failure of water supply system | Faulty door knobs | Leakage of pipe |
|---|---|---|---|---|
| Cracking in external wall | | | | |
| Correlation | 1.000 | 0.199 | −0.037 | 0.151 |
| Significance (2-tailed) | — | 0.000 | 0.520 | 0.008 |
| Degree of frequency | 0 | 307 | 307 | 307 |
| Total failure of water supply system | | | | |
| Correlation | 0.199 | 1.000 | 0.155 | 0.126 |
| Significance (2-tailed) | 0.000 | — | 0.006 | 0.027 |
| Degree of frequency | 307 | 0 | 307 | 307 |
| Faulty door knobs | | | | |
| Correlation | −0.037 | 0.155 | 1.000 | −0.002 |
| Significance (2-tailed) | 0.520 | 0.006 | — | 0.971 |
| Degree of frequency | 307 | 307 | 0 | 307 |
| Leakage of pipe | | | | |
| Correlation | 0.151 | 0.126 | −0.002 | 1.000 |
| Significance (2-tailed) | 0.008 | 0.027 | 0.971 | — |
| Degree of frequency | 307 | 307 | 307 | 0 |

Site supervision and monitoring is required by both the client team and the main construction company. It is important for the client team to carry out site supervision and inspections periodically; construction workers tend to properly execute work when there are client representatives to supervise their work, or when a client representative may suddenly appear. The same applies to the main contractor. Because much of the construction work is subcontracted, it is crucial for the main contractor to monitor the work instead of just managing the coordination of work among all subcontractors.

Because most of the defects in affordable housing can occur because of poor workmanship, employing more skilled workers may also improve the overall quality of construction. Many training sessions for laborers are provided by CIDB, with the aim of providing more skilled workers to the Malaysian construction industry. Thus, contractors may also send their laborers to attend these training sessions, improving the workers' skills, and creating a higher quality final product.

### *Leakage of Pipes*

From the questionnaire findings, leaking pipes were identified as the most frequent defect in affordable housing in Klang Valley. This defect occurred in the both external walls and wet areas, such as the kitchen and toilet. This finding is supported by Georgiou et al. (1999), whose study compared defects in constructions by owners and registered builders and found that both external walls and wet areas had plumbing defects as major defects. However, this finding is similar to the conclusions reached by Chew (2005), who only focused on defects in the wet areas of buildings. Chew identified water leakage through pipe penetration to be the fourth most frequently occurring defect. Pipe leakages were identified as the most commonly occurring defect because affordable housing has piping systems above ground, rather than underground; such construction simplifies later maintenance work, but exposes pipes to increased risk of damage over time. Therefore, pipe leakage occurs easily and is the most frequently occurring defect in affordable housing.



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**Table 14.** Partial Correlation Matrix of the Variables, Controlling for Faulty Door Knobs

| Control Variables | Cracking in external wall | Total failure of water supply system | Concrete wall dampness | Leakage of pipe |
|---|---|---|---|---|
| Cracking in external wall | | | | |
| Correlation | 1.000 | 0.247 | 0.576 | 0.412 |
| Significance (2-tailed) | — | 0.000 | 0.000 | 0.000 |
| Degree of frequency | 0 | 307 | 307 | 307 |
| Total failure of water supply system | | | | |
| Correlation | 0.247 | 1.000 | 0.139 | 0.181 |
| Significance (2-tailed) | 0.000 | — | 0.015 | 0.001 |
| Degree of frequency | 307 | 0 | 307 | 307 |
| Concrete wall dampness | | | | |
| Correlation | 0.576 | 0.139 | 1.000 | 0.535 |
| Significance (2-tailed) | 0.000 | 0.015 | — | 0.000 |
| Degree of frequency | 307 | 307 | 0 | 307 |
| Leakage of pipe | | | | |
| Correlation | 0.412 | 0.181 | 0.535 | 1.000 |
| Significance (2-tailed) | 0.000 | 0.001 | 0.000 | — |
| Degree of frequency | 307 | 307 | 307 | 0 |

**Table 15.** Partial Correlation Matrix of the Variables, Controlling for Leakage of Pipe

| Control Variables | Cracking in external wall | Total failure of water supply system | Dampness to concrete wall | Faulty door knobs |
|---|---|---|---|---|
| Cracking in external wall | | | | |
| Correlation | 1.000 | 0.187 | 0.460 | −0.019 |
| Significance (2-tailed) | — | 0.001 | 0.000 | 0.736 |
| Degree of frequency | 0 | 307 | 307 | 307 |
| Total failure of water supply system | | | | |
| Correlation | 0.187 | 1.000 | 0.054 | 0.157 |
| Significance (2-tailed) | 0.001 | — | 0.343 | 0.006 |
| Degree of frequency | 307 | 0 | 307 | 307 |
| Concrete wall dampness | | | | |
| Correlation | 0.460 | 0.054 | 1.000 | 0.029 |
| Significance (2-tailed) | 0.000 | 0.343 | — | 0.610 |
| Degree of frequency | 307 | 307 | 0 | 307 |
| Faulty door knobs | | | | |
| Correlation | −0.019 | 0.157 | 0.029 | 1.000 |
| Significance (2-tailed) | 0.736 | 0.006 | 0.610 | — |
| Degree of frequency | 307 | 307 | 307 | 0 |

### Total Failure of Water Supply System

The total failure of water supply systems was identified as being the second most common defect in affordable housing. This is supported by Kazaz and Birgonul (2005), who determined that the water supply system is the most unsatisfactory product or service in high-rise and medium-density housing units. Most of the water supply systems in affordable housing in the Klang Valley operate with a pumping system, where the pump machine distributes water to each of the housing units in the block. However, there is only one pump for each block; when the pumping system fails, the water supply for the whole block will cut off because there is no backup system to distribute water. This means that failures will be clustered, and reported by several residents in the block.

### Cracking in External Walls

Generally, there are two main types of cracking in external walls. One type is caused by structural movements, which usually cause cracks that mirror the horizontal and vertical planes of the mortar joints, often varying in width and running at oblique angles. Another type of cracking is caused by temperature changes. These are usually of uniform width and cut straight through materials at the weakest, or least restrained, part of the wall (Garrand 2001). The findings herein indicate that cracking in external walls was found to be the third most common defect in Klang Valley's affordable housing. This aligns with other research, such as Olubodun and Mole (1999), who suggested that expansion cracks have the highest mean for design factors in building, and a range of previous studies that identified cracking as a commonly occurring category of defects (Georgiou et al. 1999; Georgiou 2010).

### Faulty Door Knobs

Faulty door knobs were the fourth most frequently occurring defect in affordable housing. This was most likely caused by substandard materials and poor workmanship. Workmanship is usually identified as the first or second major source of defects (Georgiou 2010). The



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present research differed from past research because faulty door knobs may be caused by poor workmanship or substandard materials.

### Concrete Wall Dampness

Traditionally, walls are protected from rainfall by overhanging eaves fitted with gutters and downpipes. Nevertheless, rain may still be blown onto the surface of the wall (Richardson 2001) and can cause dampness to concrete walls. This is particularly problematic in Malaysia, because Malaysia has heavy rainfall compared with many other countries. In this research, concrete walls dampness was identified as one of the top five most commonly occurring defects in affordable housing. This conclusion is supported by previous research (Georgiou et al. 1999); however, the ranking herein for the occurrence may be different, because of the fact that other countries have different rainfall patterns, and therefore, dampness may occur less frequently than in Malaysia.

## Conclusion and Recommendations

The research focused on affordable housing in the Klang Valley, Malaysia, where more than 70% of housing stock consists of units in affordable market segments. These include terraced houses, low-cost houses, and low-cost flats. The key findings are that the most commonly occurring defects in affordable housing are leaking pipes, total failure of water supply systems, cracking in concrete walls, concrete wall dampness, and faulty door knobs. The first three of these defects are strongly correlated, suggesting a common underlying cause that may be readily identified and rectified. This may be the cracking of external walls, which affects the water pipes, causes leaks, and allowing for this, plus rainfall, causes increased dampness in the walls. The common causes of these defects may be poor workmanship, inferior materials, and poor supervision and monitoring routines. Increasing involvement of client-oriented monitoring and supervision on the worksite may improve subcontractor performance, influencing the quality of the final job. This may be particularly pertinent to the construction of the external walls, given the relationship between defective construction of walls and the presence of other construction defects. These findings have been reported to the CIDB of Malaysia to improve the quality of affordable housing.

A number of areas that would be worth investigating further, because they might prove to be beneficial to the industry, have been identified. First, the study could be broadened to understand the defects in affordable housing over all of Malaysia, or the entire South East Asian region, particularly emphasizing how housing quality could also be improved in rural areas. Second, defects could be compared in low-cost projects constructed by the public and private sectors. Public sector bodies would be expected to be more accountable and should have correspondingly fewer defects than private sector firms. This might be informed by a more detailed investigation into the defects associated with the People Housing Program (PHP). Third, because it was not possible to determine causes of defects with the current research design, follow-up research focusing on the industry and construction techniques might uncover the causes of the defects, and how they could be prevented. Fourth, because construction methods and political expediency influence the construction of affordable housing over time, the differences in quality in recent affordable housing units compared with those constructed before 2000 would be interesting to study and might indicate the problems in societal and political influences that lead to greater levels of defects. Fifth, broader research could be conducted to understand how society can overcome challenges to providing sustainable urban development of affordable housing solutions in Malaysia.

## References


Abdellatif, M. A., and Othman, A. A. E. (2006). "Improving the sustainability of low-income housing projects: The case of residential buildings in Musaffah commercial city, Abu Dhabi." *Emirates J. Eng. Res.*, 11(2), 47–58.

Ariffian, B. A., Abu Zarin, H., and Jumadi, N. (2010). "The relationship between demographic factors and housing affordability." *Malaysian J. Real Estate*, 5(1), 49–58.

Auchterlounie, T. (2009). "Recurring quality issue in the UK private house building industry." *Struct. Surv.*, 27(3), 241–251.

CBRE. (2010). "CB Richard Ellis's 2009 review and 2010 outlook for commercial real estate in Europe: Key commentary from CBRE's forthcoming report—after the storm: where next for European property?" ⟨http://www.cbre.com/EN/aboutus/MediaCentre/2010/Pages/011110.aspx⟩ (Nov. 10, 2010).

Chan, A. P. C., Wong, F. K. W., and Lam, P. T. L. (2006). "Assessing quality relationship in public housing: An empirical study." *Int. J. Qual. Reliab. Manage.*, 23(8), 909–927.

Chew, M. Y. L. (2005). "Defects analysis in wet areas of buildings." *Construct. Build. Mater.*, 19(3), 165–173.

Cohen, L., Manion, L., and Morrison, K. (2007). *Research methods in education*, Taylor & Francis Group, London.

De Vaus, D. A. (2004). *Surveys in social research*, Routledge, Australia.

Forsythe, P. (2008). "Modelling customer perceived service quality in housing construction." *Eng. Construct. Architect. Manag.*, 15(5), 485–496.

Garrand, C. (2001). *HAPM guide to defect avoidance*, Spon Press, London.

Georgiou, J. (2010). "Verification of a building defect classification system for housing." *Struct. Surv.*, 28(5), 370–383.

Georgiou, J., Love, P. E. D., and Smith, J. (1999). "A comparison of defects in houses constructed by owners and registered builders in the Australia state of Victoria." *Struct. Surv.*, 17(3), 160–169.

Government of Malaysia. (2010). *Tenth Malaysia plan, 2011-2015*, Government Press, Kuala Lumpur, Malaysia.

Hall, M., and Tomkins, C. (2001). "A cost of quality analysis of a building project: Toward a complete methodology for design and build." *Construct. Manag. Econ.*, 19(7), 727–740.

Hammarlund, Y., and Josephson, P. E. (1991). "Source of quality failure in building." *Proc., European Symp. on Management Quality and Economic in Housing and Other Building Sector*, Technical Univ. of Lisbon, Lisbon, Portugal, and Univ. of Salford, Salford, U.K., 671–679.

Holmstrom, B. (1979). "Moral hazard and observability." *Bell J. Econ.*, 10(1), 74–91.

Ilozor, B. D., Okoroh, M. I., Egbu, C. E., and Archicentre. (2004). "Understanding residential house defects in Australia from the state of Victoria." *Build. Environ.*, 39(3), 327–337.

Karim, K., Marosszeky, M., and Davis, S. (2006). "Managing subcontractor supply chain for quality in construction engineering." *Construct. Architect. Manage.*, 13(1), 27–42.

Kazaz, A., and Birgonul, M. T. (2005). "The evidence of poor quality in high rise and medium rise housing units: A case study of mass housing projects in Turkey." *Build. Environ.*, 40(11), 1548–1556.

Lodico, M. G., Spaulding, D. T., and Voegtle, K. H. (2010). *Methods in education research: From theory to practice*, 2nd Ed., Jossey-Bass, San Francisco.

Lourenco, P. B., Luso, E., and Almeida, M. G. (2006). "Defects and moisture problems in buildings from historical city centres: A case study in Portugal." *Build. Environ.*, 41(2), 223–234.

Ministry of Finance's Valuation and Property Service Department. (2009). *Property market report*, Government Press, Kuala Lumpur.

Nunnally, J. (1978). *Psychometric theory*, McGraw Hill, New York.

Olubodun, F. (2000). "A factor approach to the analysis of components' defects in housing stock." *Struct. Surv.*, 18(1), 46–57.

Olubodun, F., and Mole, T. (1999). "Evaluation of defect influencing factors in public housing in the UK." *Struct. Surv.*, 17(3), 170–178.

Omar, D. (2008). "Communal living environment in low cost housing development in Malaysia." *Asian Social Sci.*, 4(10), 98–105.

Ong, S. E. (1997). "Building defects, warranties and project financing from pre-completion marketing." *J. Property Finance*, 8(1), 35–51.


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Peterson, R. A. (1944). *Constructing effective questionnaires*, Sage, New York.

Pheng, L. S., and Wee, D. (2001). "Improving maintenance and reducing building defects through ISO 9000." *J. Qual. Mainten. Eng.*, 7(1), 6–24.

Rinker, M. E. (2008). "Subdivision requirements as a regulatory barrier to housing affordability." *Affordable Housing Issues*, Shinberg Center for Affordable Housing, Gainesville, FL, XIX(5), 1–4.

Rogerson, E. (1985). "The first order approach to the principal-agent problem." *Econometrica*, 53(6), 1357–1368.

Shavell, S. (1979). "Risk sharing and incentive in the principal and agent relationship." *Bell J. Econ.*, 10(1), 55–73.

Sufian, A., and Abdul-Rahman, R. (2008). "Quality housing: Regulation and administrative framework in Malaysia." *Int. J. Econ. Manage.*, 2(1), 141–156.

Teck-Hong, T. (2011). "Neighborhood preferences of house buyers: The case of Klang Valley, Malaysia." *Int. J. Housing Market Anal.*, 4(1), 58–69.

Trevor, R. (2009). *Investigating defects in commercial and industrial buildings*, RICS Books, Coventry, U.K.

Watt, D. S. (1999). *Building pathology: Principles & practice*, Blackwell Zealand, Oxford, U.K.

Zaid, N. S. M., and Graham, P. (2011). "Low-cost housing in Malaysia: A contribution to sustainable development?" *Proc., Energy, Environment and Sustainability*, 82–87.

Zain-Ahmed, A., Sayigh, A. A. M., Surendran, P. N., and Othman, M. Y. (1998). "The bioclimatic design approach to low-energy building in the Klang Valley, Malaysia." *Renew. Energy*, 15(1–4), 437–440.



J. Perform. Constr. Facil. 2014.28:272-285.

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