DEFECTS IN AFFORDABLE HOUSING PROJECTS IN KLANG VALLEY, MALAYSIA

Hamzah Abdul-Rahman[1], Chen Wang[2], Lincoln C. Wood[3], You Min Khoo[4]

[1] Professor, Ph.D, Faculty of Built Environment, University of Malaya, 50603 Kuala Lumpur, Malaysia Tel: +603-7967 3203 Fax: +603-796 7 5713

[2] Senior Lecturer, Ph.D, Faculty of Built Environment, University of Malaya, E: derekisleon@gmail.com

[3] Senior Lecturer, School of Information Systems, Curtin University, Australia

[4] Research Fellow, Ph.D, Faculty of Built Environment, University of Malaya, E:

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ABSTRACT

Several affordable housing programs have been introduced by the government to achieve the objectives of several Malaysia Plans; however, the success of the housing programs has been reduced due to readily reported quality problems and defects. This research aims to identify the types of defects in affordable housing and 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 of affordable housing, located in four different regions in Klang Valley, Malaysia. The most commonly occurring defects in affordable housing are leaking pipes, total failure of water supply systems, cracking in concrete walls, faulty door knobs, and dampness to concrete walls. This suggests that improvements in workmanship, the 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.

Keywords: Defects dissection, Low cost housing, Affordable housing, Building defects, Building quality

INTRODUCTION

The low cost housing has always been criticised for poor quality and defective outcomes (Elias, 2003; Abdellatif and Othman, 2006). Rinker (2008), in his report on affordable housing issues, pointed out that public housing projects have deteriorated badly due to a combination of hasty construction, poor design, and insufficient maintenance. Frequently, customers and end-users of low-income building projects complain that their accommodation does not meet their expectations and are not designed to suit their requirements (Abdellatif and Othman, 2006). Construction defects could be due to substandard construction strategies, faulty workmanship inside and outside the house, bad building materials, improper soil analysis, and 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 sub-standard construction of houses (Sufian and Abdul-Rahman, 2008). Despite the Malaysian government's commitment in providing adequate, affordable and quality houses for all income level groups with emphasis on the development of low cost housing, there continues to be challenges in developing the housing sector (Ariffian et al., 2010). The low cost housing provided did not meet the demands of the 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 suffer from a variety of defects in Malaysia. There has also been a widely-reported case where the residents from the Rista Villa apartments, in Taman Putra Perdana, complained that there were huge cracks appearing at the bottom of the apartment and 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. As the architects are frequently employed by the developers, home buyer scepticism of their credibility is unsurprising (Sufian and Abdul-Rahman, 2008). Therefore, house purchasers often face difficulties in evaluating the physical construction quality (Forsythe, 2008).

Klang Valley is a region in Peninsula Malaysia which comprises the capital city of Malaysia, Kuala Lumpur, and surrounding suburbs as shown in Figure 1. Also known as the Kuala Lumpur conurbation, it is the fastest growing region in Malaysia (Tan, 2011) and has a population of around 7.2 million in an area of about 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 were located in the Klang Valley. Due to the importance of affordable housing in this rapidly growing region, the of this study is to identify the types and causes of frequently occurring construction defects within the affordable housing in the Klang Valley, Malaysia.

AFFORDABLE HOUSING IN KLANG VALLEY, MALAYSIA

Affordable housing was defined as appropriate housing units of which the construction is in accordance with standards comply with code of practice specially created for low cost houses as stated in CIS 1: 1998 and CIS 2:1998 which were publish by CIDB. Defined in the context of Malaysia, a low-cost house is a living unit with a selling price ranging from RM 25,000 to RM 42,000 based on the value of land developed. Affordable housing could be a terrace, detached house or flat with minimum design specifications of a built up area between 600-750 sq feet, with a living room, a dining area, a kitchen, a bathroom, three bedrooms, a washing and a drying area. Those eligible to own a unit under the low cost housing are those with a monthly household income ranging from RM750-RM1500. In some cases, houses may be rented out at a low monthly rate. To improve the quality of life, social facilities like religious centres, 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 of 2009, the property market was expecting the positive sentiment to continue in 2010, witnessing a fresh enthusiasm and high levels of activity. This may be linked to overall bullish economic sentiment for 2010, as regional investors became increasingly interested in the Malaysian property market (CBRE, 2010).

There are a total 100,105 units of existing 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, about 37% of the affordable housing in Klang Valley; over 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 large type which makes up 22% from all type 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: a) self-administration in the presence of the researcher, and b) self-administered questionnaires without the presence of the researcher. Self-administered questionnaires in the presence of the researcher were used during this research project as 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 researcher, is that respondents may misunderstand, or have difficulties understanding the questions, which leads to inaccurate answers or no answer. The researchers felt that this was a particular risk, particularly for those respondents that live in the affordable housing areas and do not have any formal education, as many of them are senior citizens.

There were 310 participants involved in the research, who live in affordable housing residences in the Klang Valley. Since 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 the year 2011 after a pilot study. The sample size is similar to Omar’s (2008) study, 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, thus the details have a great extent of reliability. Data analysis was conducted using the following tests including: a) Cronbach's Alpha, b) Frequency Analysis, c) One Sample T-Test, d) Scale Index Analysis, e) Scale Index Analysis, f) Correlation, and g) 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 respondent were female. Most of the respondents are more than 31 year old; the highest numbers of respondents are more than 50 years old. This may be due to the distribution of questionnaires being conducted during the weekday during 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 likely because residents from Taman Desa Ria and PPR Kampung Baru Air Panas, which are two of the affordable housing areas where the questionnaire was distributed, only started to move in only around six years before the research. 31.6% had residency lengths greater than 10 years; 29% had habitation periods of 1-3 years; only 2.9% had a length of residency of 7-10 years. 60% had, at the highest, secondary education; 27.4% of respondents had the highest level of education at the primary school level; only 9.4% of respondents had tertiary education.

Approximately 44% of respondents had a monthly family income between RM1001-1500. While 27 (8.9%) of them have monthly family income level less than RM500; 107 (35.3%) of respondents have monthly family income level between RM500 – RM 1000 and lastly 36 (11.9%) numbers of respondents have monthly family income level more than RM1500. However, around 2.3% 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 total of 25 variables is 0.855 (Table 5) which is also an acceptable reliability 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), the variables with Corrected Item-Total Correlation value lower than 0.30 should be removed; as all of the Corrected Item-Total Correlation values exceeded 0.30, no variables were removed. Furthermore, the last column in Table 5 displayed the Cronbach's Alpha if item deleted with the purpose to determine variable to contribute to the overall alpha value. The removal of any one variable only causes minor differences to the overall Cronbach's alpha and so 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 occur in low cost housing. The frequency for each type of defect, including their corresponding percentage, mean, standard deviation, and rank are tabulated in Table 6. A total of 25 defects are rank from 1 to 25.

The most frequently occurring defect was leaking pipes (mean value at 2.59); around 16.1% of respondents acknowledged that this defect was very frequently a problem in their housing area. This includes 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 water supply system (mean value of 2.48, slightly lower than for leaking pipes); 9.4% of participants claimed that the water supply to their housing unit failed very frequently.

Cracks in the external walls had the third highest mean and 24.2% of residents reported that this defect occurred very frequently. Moreover, this defect also has the highest standard deviation figure (SD = 1.21) of all the defects, representing significant volatility of opinion amongst respondents. Other significant defects included faulty door knobs (mean of 2.25) and dampness to concrete wall (mean of 1.94). These four defects have similar mean values, allowing us to claim that these are the most frequently observed defects in the construction of affordable housing in Klang Valley.

One Sample T-Test

One sample t-tests were utilised to identify whether the various defects occurred in affordable housing in Klang Valley. Since for “never” occur scale of defect is 1 and “rarely” occur scale of defect is 2, the test value is set at 1.5 for occurrence of defects in low cost housing. The test value is set at 1.5 instead of 4 which the very frequent occurrence defect because it is not logic for a house unit to has all defects listed in questionnaire occur frequently as it is unsafe for a living space. Hence, this test is to examine defect that exist in low cost housing and among them identify the most frequent occurrence defects. The hypotheses are shown as follows:

H_0: $\mu = 1$ (This hypotheses represent that defect has never occur in low cost housing)

H_A: $\mu \geq 1$ (This hypotheses represent that defect has occur in low cost housing)

The output of one sample t-test is displayed in Table 7. The second column of the table represent the t-statistical value obtains, and the third column is the p-value of the test. To interpret the results of one sample t-test, each of the variables are compared with two-tailed critical t value of ±1.965, obtained representing 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 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 which have significant level less than 0.05.

Categories for Each Type 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).

Average Scale Deviation, x=(maximum mean-minimum mean)/number of scale

(1)

Knowing the value of average scale deviation, the degree of frequency for "never", "rarely", "frequent" and "very frequent" are illustrated in Eq. (2), Eq. (3), Eq. (4) and Eq. (5) respectively.

Index scale for "never" = minimum mean $+x = x_1 + x = x_2$ *(2)*

(Degree of frequency for "never" is $x - x_2$*)*

Index scale for "rarely" $= x_2 + x = x_3$ *(3)*

(Degree of frequency for "rarely" is $> x_2 - x_3$*)*

Index scale for "frequent" $= x_3 + x = x_4$ *(4)*

(Degree of frequency for "rarely" is $> x_3 - x_4$*)*

Index scale for "very frequent" $= x_4 + x = x_5$ *(5)*

(Degree of frequency for "rarely" is $> x_4 - x_5$*)*

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 are almost never observed in Klang Valley, and this categorisation of infrequent occurrence contains the greatest proportion of defects, with mean values ranging from 1.16 to 1.52. These defects include all those relating to the roof (water staining, mould 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 are less problem-prone than other elements of construction in affordable housing in Klang Valley. Eight types of defects (32%) are considered to be rarely occurring, with mean values ranging from 1.52 to 1.88. These include internal staining, mould growth as well as fungal decay on external wall, inadequate resistance to the passage of sound, distortion and cracking of partition, uneven floor finishes, broken window knobs, faulty sanitary installation, faulty electrical fitting and leakage of water tank. The number of ‘rarely’ occurring defects are second only to the number of ‘never’ occurring defects, and consist primarily of defective problems relating to internal walls and flooring. Cracking in external walls, total failure of water system, faulty doors and knobs, and leakage of pipes are all considered to occur very frequently. Interestingly, only one defect, dampness to concrete wall, is 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 where one defect is present the other tends to be absent.

Three defects, the cracking in external walls, dampness of concrete walls, and leaking pipes, are all significantly correlated. There is a strong relationship between cracking in external walls and dampness to concrete wall ($r = 0.575$ and the correlation is significant at the 1% level). This may occur as water is able to penetrate between the cracks in the wall and cause dampness in concrete wall. There is also a strong correlation between dampness to concrete wall and the leakage of pipes ($r = 0.535$, significant at the 1% level). This is probably due to water from the leaking pipes collecting and consequently dampening the concrete walls. Leaking pipes are moderately correlated with cracking in external walls ($r = 0.412$, significant at the 1% level). These three defects are correlated and may be jointly caused as the piping systems may be laid in concrete walls; when a concrete wall cracks, or there is movement in the wall, the pipe laid in the wall may break, causing the release of water. The, total failure of water supply systems was weakly correlated with cracking in external walls, dampness to concrete walls, faulty door knobs.

Partial Correlation Matrix of Variables Controlling for Total Failure

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

Partial Correlation Matrix of the Variables, controlling for cracking in external wall

By removing the variation associated with cracking in external walls, as illustrated in Table 11, the results of correlation between two defects are compared with the correlation output in Table 10. The correlation coefficients between dampness to concrete wall 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 are not affected greatly by controlling for the cracking in 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 dampness to concrete walls and cracking in external walls (r = 0.563), and the correlation between leaking pipes and dampness to concrete wall (r = 0.524), both remain high and significant at the 1% level. This indicates that relationships between the pairs of defects remain strong, irrespective of the failure of water supply systems.

Partial Correlation Matrix of the Variables, controlling for dampness to concrete wall

Generally, all the coefficient value for all variables has decreased when the dampness to concrete walls is controlled for (Table 13); this defect is significantly associated with other defects. Therefore, many other defects can 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) is less strong than it is if the dampness to concrete walls is not controlled for (r = 0.412); the coefficient decrease by 0.261. In other words, the correlation between them is influenced by dampness to concrete wall.

Partial Correlation Matrix of the Variables, controlling for faulty door knobs

It can be said that the correlations between defects are not markedly affected by controlling for faulty door knobs (Table 14) indicates that some coefficients increase while others decrease). This means that defective door knobs have little impact on other defects.

Partial Correlation Matrix of Variables, controlling for leakage of pipe

There is a clear correlation between cracking in external walls and dampness to concrete walls (Table 15), where the relationship decreases from a strong (r = 0.575) to moderate (r = 0.460) relationship when the leaking pipes are controlled for, while still significant at the 1% level. This is clearly seen in the correlation between cracking in external and dampness to concrete wall where the relationship between from decrease from strong to moderate with the p-value at less than 1% significant level relative to output of correlation. This result may occur as without leaking pipes inside the concrete walls, there will be no water flow through cracks in external walls, and therefore the dampness to the concrete will decrease. In other words, the defects of cracking in external walls and dampness to concrete walls will likely be strongly reduced through careful and proper installation of piping systems.

DISCUSSION ON FINDINGS

With the increase in demand for housing, mainly due to 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. Our research found that most participants identified defects that were similar to those identified through the literature review. Results from the questionnaire shows the most common defect occurring in affordable housing is leaking pipes. Approximate 17% of low cost housing residents admitted that pipe leakage always happen in their housing unit and about 40% report that leakage of piping is a frequent problem for them. Another significant problem is the total failure of water supply system. This defect has created many inconveniences to residents; without water supply, many core household activities are simply not possible. Cracking in walls is a commonly occurring defect that occurs in almost all housing units, whether they are low-, medium-, or high-cost housing. It is undeniable that cracking in external walls is another common defect in affordable housing. While cracks are the third most frequently occurring defect in affordable housing, 75% revealed that this defect happens very frequently in their housing unit; this indicates that cracking of walls is a very widely spread problem, while the leaking pipes and water supply problems may be isolated to a smaller number of construction projects. Another two frequently occurring defects are dampness to concrete walls and faulty door knobs. Although these five defects are considered as the most frequent defects in low cost housing, dampness to concrete wall is found to be a defect that is described as a "frequent" occurrence, while the others are attributed as "very frequent" occurrences. Thus, from the findings of questionnaire survey, it was proven that there is quality problem is faced by residents in affordable housing.

There are also significant correlations between the top five frequent defects. Moderate or strong correlations exist between the defects of cracks in external walls, leaking pipes, and dampness to concrete walls. This indicates that when one of the defects exists, it is likely that the others will occur simultaneously. This indicates that one of the defects is causing the other two, or that there is a fourth, unseen, influence that is possibly causing all three defects. It seems likely, however, that properly constructed external walls may prevent cracking of concrete walls and this may prevent the other defects from occurring, particularly leaking pipes.

The respondents are drawn from five different areas of affordable housing located in Klang Valley, two of which were constructed under the PPR affordable housing project. Some of the residences were completed about ten years ago, while some were completed less than five years ago. Residents from various affordable housing programs, covering different periods of habitation, were chosen as respondents because the research aims to collect information adequate 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 such affordable housing. The first factor is to increase the ceiling, or selling price, of low cost housing, or to secure larger government subsidies. This can be considered as the main factor as other factors are also related to this factor. Due to construction cost pressures driven largely by a low ceiling price, many constructors may have opted for materials of low quality and employed unskilled labour to undertake work, which reduces their costs. Another cost-related issue is the land value in Klang Valley, which is higher than many other Malaysian states, as this causes otherwise identical low-cost developments to be higher-cost than in other states. Therefore, an increase of 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 may be directed towards securing high quality materials, or ensuring a steady supply of skilled labourers, to support the construction industry.

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 inspection trips from time-to-time; 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 goes to the main contractor: as much of the construction work is subcontracted, it is crucial for the main contractor to monitor the work instead of managing the coordination of work among all subcontractors.

As most of the defects in affordable housing can be due to 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 occurs in the both external and walls and wet areas, such as the kitchen and toilet. This is supported by Georgious et al. (1999) conclusions, reached in a study comparing defects found in constructions by owners and registered builders, which found that both categories led to plumbing defects as major defects. However, our finding is similar to the conclusions reached by Chew (2005), which 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. The leakage of piping was identified as the most commonly occurring defect mainly due as affordable housing have piping systems above ground, rather than being 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.

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 as 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 Wall

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 is 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). Our findings indicate that cracking in external walls was found to be the third most common defect Klang Valley’s affordable housing. This is aligned with other research, such as Olubodun and Mole (1999) suggesting 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 (Georgious et al. 1999; Trotman, 1994; Georgious, 2010).

Faulty Door Knobs

The fourth most frequently occurring defect in affordable housing that we identified is faulty door knobs. This is most likely due to substandard materials being utilized and poor workmanship. Workmanship is usually identified as the first or second major source of defects (Georgious, 2010). The present research differs from past research as the faulty door knob may be caused by poor workmanship or substandard materials.

Dampness to Concrete Wall

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 wall. This is particularly problematic in Malaysia, as it is considered to have a heavy rainfall in comparison to many other countries. In this research, dampness to concrete walls was identified as one of the top five commonly occurring defects in affordable housing. This conclusion is supported by previous research (Trotman, 1994; Georgious et al., 1999); however, our ranking for the occurrence may be different and this is likely to be due to the fact that other countries have different rainfall patterns, and so dampness may occur less frequently than in Malaysia.

CONCLUSION AND RECOMMENDATIONS

The research is 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. They 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, dampness to concrete walls, 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, causing leaks, and allowing this, plus rainfall, to cause increased dampness in the walls. We infer that the common causes of these defects may be poor workmanship, inferior materials, and poor supervision and monitoring routines. Increasing involvement of clients-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 Construction Industry Development Board of Malaysia to improve the quality of affordable housing.

A number of areas which would be worth investigating further, as they may 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 emphasising how housing quality can also be improved in rural areas. Second, defects could be compared in those 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 may be informed by a more detailed investigation into the defects associated with the People Housing Program (PHP). Third, as it is not possible to determine causes of defects with our current research design, follow-up research focusing on the industry and construction techniques may uncover the causes of the defects, and how they can be prevented. Fourth, as 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 and may indicate problems in societal and political influences that lead to greater levels of defects. Fifth, broader research can be conducted to understand how society can overcome challenges to providing sustainable urban development of affordable housing solutions in Malaysia.

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Figure Caption:

Figure 1: Location of Klang Valley, Malaysia shown in read pane (http://www.malaxi.com/highway_express/images/plus_expressways_map.jpg)

Table 1: Summary on types of building defects

Type of defects	**Authors**
Foundation and floor structure i. 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), Georgious (2010).
External walls i. 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), Georgious (2010), Thwala (2010)
ii. Internal staining, mould growth and fungal decay	Garrand (2001), Chew (2005), Lourenco et al. (2006)
Roof i. Water staining, mould growth and fungal decay	Ilozor *et al* (2004), Garrand (2001), Chew (2005), Thwala (2010)
ii. Deterioration of coverings	Olubodun and Mole (1999), Olubodun (2000), Garrand (2001), Ilozor *et al.* (2004), Lourenco et al. (2006), Thwala (2010)
iii. Deformation or displacement of roof	Olubodun and Mole (1999), Olubodun (2000), Garrand (2001), Ilozor *et al.* (2004), Thwala (2010)
Internal walls and floors i. Inadequate resistance to the passage of sound ii. Distortion and cracking of partition	Watt (1999), Garrand (2001) , Olubodun and Mole (1999), Olubodun (2000), Garrand (2001), Ilozor *et al.* (2004), Kazaz and Birgonul (2005), Lourenco et al. (2006), Georgious (2010), Thwala (2010)
Above ground service i. Failure of water supply system	Garrand (2001), Ilozor *et al* (2004), Kazaz and Birgonul (2005), Georgious (2010)
ii. Poor ventilation system	Watt (1999), Garrand (2001)

Below ground drainage and external works i. Surcharge of drains and flooring ii. Fracture and displacement of drains	Olubodun and Mole (1999), Olubodun (2000), Garrand (2001), Kazaz and Birgonul (2005), Georgious (2010)
Wall and floor finishes i. Uneven floor finishes	Georgiou et al. (1999), Chew (2005)
ii. Uneven wall plaster	Georgiou et al. (1999), Kazaz and Birgonul (2005)
iii. Broken floor tiles	Kazaz and Birgonul (2005), Chew (2005),
iv. Broken wall tiles	Olubodun and Mole (1999), Olubodun (2000), Kazaz and Birgonul (2005), Chew (2005),
Damp proof course i. Dampness to concrete wall	Watt (1999), Olubodun (2000), Georgious (2010)
ii. Floor dampness	Olubodun and Mole (1999), Olubodun (2000), Georgious (2010)
Door and window fixings i. Faulty door knobs	Olubodun (2000), Kazaz and Birgonul (2005)
ii. Broken window knobs	Olubodun and Mole (1999), Olubodun (2000), Kazaz and Birgonul (2005)
Sanitary installation i. Faulty sanitary installation	Kazaz and Birgonul (2005)
Electrical installation i. Exposed wires	Georgiou et al. (1999)
ii. Faulty electrical fittings	Olubodun and Mole (1999), Georgiou et al. (1999), Olubodun (2000), Ilozor *et al.* (2004), Kazaz and Birgonul (2005)
Piping work i. Leakage of pipe	Olubodun and Mole (1999), Georgiou et al. (1999), Olubodun (2000)

Table 2: Summary on causes of defects

Causes	Authors
Design	Olubodun and Mole (1999), Olubodun (2000), Low 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. (2005)
User involvement	Hammarlund et al. (1990)
Time pressure	Low and Wee (2001), Hammarlund et al. (1990)
Cost pressure	Low and Wee (2001)
Workers problem	Thwala (2010), Hammarlund et al. (1990),
External influence	Olubodun (2000)
Tenant's lack of care	Olubodun (2000)
Material selection	Low and Wee (2001), Chew (2005), Thwala (2010), Karim et al. (2006)

Poor site investigation	Low and Wee (2001), Thwala (2010)
Management	Hammarlund et al.(1990), Chan et al. (2005)
Workmanship	Chew (2005), Chan et al. (2005), Karim et al. (2006), Hall and Tomkins (2001)
Lack of quality	Chan et al. (2005), Thwala (2010)

Table 3: Regional distribution of respondents

Low Cost Housing Area	Number of Questionnaire distributed	Percentage (%)
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

Table 4: Respondents’ profiles

Social-demographic characteristics	Frequency (n=310)	Percentage (%)
Ownership		
➢ Owner	168	54.2
➢ Tenant	142	45.8
Gender		
➢ Male	129	41.6
➢ Female	181	58.4
Age		
➢ 18-25 year old	28	9.0
➢ 26-30 year old	41	13.2
➢ 31-40 year old	63	20.3
➢ 41-50 year old	80	25.8
➢ More than 50 year old	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 – RM1000	107	34.5
➢ RM1001 – RM1500	133	42.9
➢ More than RM1500	36	11.6
Missing	7	2.3

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	.460	.849
Cracking in external wall	38.7065	63.386	.474	.849
Internal staining, mould growth and fungal decay on external wall	39.3774	66.372	.505	.847
Water staining, mould growth and decay on roof	39.7645	68.459	.498	.848
Deterioration of roof covering	39.8355	69.206	.496	.849
Deformation and displacement of roof	39.8032	69.667	.457	.850
Inadequate resistance to the passage of sound	39.3419	65.061	.586	.844
Distortion and cracking of partition	39.2613	65.805	.604	.844
Total failure of water supply system	38.5387	66.793	.426	.849

Poor ventilation system	39.5645	67.334	.509	.847
Surcharge of drains and flooring	39.8548	69.950	.235	.855
Fracture and displacement of drains	39.7097	68.466	.513	.848
Uneven floor finishes	39.4839	67.254	.470	.848
Uneven wall plaster	39.5032	67.681	.411	.850
Broken floor tiles	39.5194	67.849	.364	.852
Broken wall tiles	39.5935	66.753	.504	.847
Dampness to concrete wall	39.0742	65.480	.476	.848
Faulty door knobs	38.7645	70.964	.104	.861
Broken window knobs	39.2710	67.700	.473	.848
Faulty sanitary installation	39.3935	68.078	.432	.849
Exposed wires	39.6290	68.590	.349	.852
Faulty electrical fitting	39.4355	65.567	.612	.843
Leakage of pipe	38.4226	66.077	.422	.850
Dampness to floor	39.6000	72.759	-.010	.863
Leakage of water tank	39.4032	71.361	.088	.861

Table 6: Defects in low cost housing

Type of Defect	Never		Rarely		Frequent		Very Frequent		Mean	Standard Deviation	Rank
	Frequency	(%)	Frequency	(%)	Frequency	(%)	Frequency	(%)			
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, mould 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, mould 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

Table 7: One-sample t-test

Type of defects	Test Value = 1.5; df=309					
	t	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference		Significance?
				Lower	Upper	
Distortion and cracking of ground floor	-.519	.604	-.01935	-.0928	.0541	Not significant
Cracking in external wall	12.718	.000	.80968	.6844	.9350	Significant
Internal staining, mould growth and fungal decay on external wall	3.259	.001	.13871	.0550	.2225	Significant
Water staining, mould growth and decay on roof	-8.272	.000	-.24839	-.3075	-.1893	Significant
Deterioration of roof covering	-12.564	.000	-.31935	-.3694	-.2693	Significant
Deformation and displacement of roof	-11.879	.000	-.28710	-.3347	-.2395	Significant
Inadequate resistance to the passage of sound	3.910	.000	.17419	.0865	.2618	Significant
Distortion and cracking of partition	6.454	.000	.25484	.1771	.3325	Significant
Total failure of water supply system	21.214	.000	.97742	.8868	1.0681	Significant
Poor ventilation system	-1.330	.184	-.04839	-.1200	.0232	Not significant
Surcharge of drains and flooring	-8.738	.000	-.33871	-.4150	-.2624	Significant
Fracture and displacement of drains	-6.620	.000	-.19355	-.2511	-.1360	Significant
Uneven floor finishes	.817	.414	.03226	-.0454	.1099	Not significant
Uneven wall plaster	.314	.754	.01290	-.0679	.0937	Not significant
Broken floor tiles	-.073	.942	-.00323	-.0898	.0834	Not significant
Broken wall tiles	-1.921	.056	-.07742	-.1567	.0019	Not significant
Dampness to concrete wall	8.775	.000	.44194	.3428	.5410	Significant
Faulty door knobs	15.963	.000	.75161	.6590	.8443	Significant
Broken window knobs	6.737	.000	.24516	.1736	.3168	Significant
Faulty sanitary installation	3.342	.001	.12258	.0504	.1947	Significant
Exposed wires	-2.857	.005	-.11290	-.1907	-.0352	Significant
Faulty electrical fitting	2.002	.046	.08065	.0014	.1599	Significant
Leakage of pipe	21.287	.000	1.09355	.9925	1.1946	Significant
Dampness to floor	-2.184	.030	-.08387	-.1594	-.0083	Significant
Leakage of water tank	2.579	.010	.11290	.0268	.1990	Significant

Table 8: Type of defects with it 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, mould growth and fungal decay on external wall	1.64	Rarely
Roof		
Water staining, mould 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	Percentage (%)
Never	12	48.00
Rarely	8	32.00
Frequent	1	4.00
Very frequent	4	16.00

Table 10: Correlations matrix of the variables

		cracking in external wall	total failure of water supply system	dampness to concrete wall	faulty door knobs	leakage of pipe
cracking in external wall	Pearson Correlation	1	Weak	Strong	No Relationship	Moderate
	Sig. (2-tailed)					
	N	310				
total failure of water supply system	Pearson Correlation	.243**	1	Weak	Weak	Weak
	Sig. (2-tailed)	.000				
	N	310	310			
dampness to concrete wall	Pearson Correlation	.575**	.142*	1	No Relationship	Strong
	Sig. (2-tailed)	.000	.012			
	N	310	310	310		
faulty door knobs	Pearson Correlation	-.011	.158**	.033	1	No Relationship
	Sig. (2-tailed)	.847	.005	.561		
	N	310	310	310	310	
leakage of pipe	Pearson Correlation	.412**	.182**	.535**	.016	1
	Sig. (2-tailed)	.000	.001	.000	.779	
	N	310	310	310	310	310

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 11: Partial correlation matrix of the variables, controlling for total failure of cracking in external wall

Control Variables			cracking in external wall	dampness to concrete wall	faulty door knobs	leakage of pipe
total failure of water supply system	cracking in external wall	Correlation	1.000	.563	-.051	.386
		Significance (2-tailed)	.	.000	.368	.000
		df	0	307	307	307
	dampness to concrete wall	Correlation	.563	1.000	.011	.524
		Significance (2-tailed)	.000	.	.848	.000
		df	307	0	307	307
	faulty door knobs	Correlation	-.051	.011	1.000	-.013
		Significance (2-tailed)	.368	.848	.	.820
		df	307	307	0	307
	leakage of pipe	Correlation	.386	.524	-.013	1.000
		Significance (2-tailed)	.000	.000	.820	.
		df	307	307	307	0

Table 12: Partial correlation matrix of the variables, controlling for total failure of water supply system

Control Variables			total failure of water supply system	dampness to concrete wall	faulty door knobs	leakage of pipe
cracking in external wall	total failure of water supply system	Correlation	1.000	.003	.165	.092
		Significance (2-tailed)	.	.953	.004	.105
		df	0	307	307	307
	dampness to concrete wall	Correlation	.003	1.000	.048	.401
		Significance (2-tailed)	.953	.	.398	.000
		df	307	0	307	307
	faulty door knobs	Correlation	.165	.048	1.000	.023
		Significance (2-tailed)	.004	.398	.	.694
		df	307	307	0	307
	leakage of pipe	Correlation	.092	.401	.023	1.000
		Significance (2-tailed)	.105	.000	.694	.
		df	307	307	307	0

Table 13: Partial correlation matrix of the variables, controlling for dampness to concrete wall

Control Variables			cracking in external wall	total failure of water supply system	faulty door knobs	leakage of pipe
dampness to concrete wall	cracking in external wall	Correlation	1.000	.199	-.037	.151
		Significance (2-tailed)	.	.000	.520	.008
		df	0	307	307	307
	total failure of water supply system	Correlation	.199	1.000	.155	.126
		Significance (2-tailed)	.000	.	.006	.027
		df	307	0	307	307
	faulty door knobs	Correlation	-.037	.155	1.000	-.002
		Significance (2-tailed)	.520	.006	.	.971
		df	307	307	0	307
	leakage of pipe	Correlation	.151	.126	-.002	1.000
		Significance (2-tailed)	.008	.027	.971	.
		df	307	307	307	0

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	dampness to concrete wall	leakage of pipe
faulty door knobs	cracking in external wall	Correlation	1.000	.247	.576	.412
		Significance (2-tailed)	.	.000	.000	.000
		df	0	307	307	307
	total failure of water supply system	Correlation	.247	1.000	.139	.181
		Significance (2-tailed)	.000	.	.015	.001
		df	307	0	307	307
	dampness to concrete wall	Correlation	.576	.139	1.000	.535
		Significance (2-tailed)	.000	.015	.	.000
		df	307	307	0	307
	leakage of pipe	Correlation	.412	.181	.535	1.000
		Significance (2-tailed)	.000	.001	.000	.
		df	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
leakage of pipe	cracking in external wall	Correlation	1.000	.187	.460	-.019
		Significance (2-tailed)	.	.001	.000	.736
		df	0	307	307	307
	total failure of water supply system	Correlation	.187	1.000	.054	.157
		Significance (2-tailed)	.001	.	.343	.006
		df	307	0	307	307
	dampness to concrete wall	Correlation	.460	.054	1.000	.029
		Significance (2-tailed)	.000	.343	.	.610
		df	307	307	0	307
	faulty door knobs	Correlation	-.019	.157	.029	1.000
		Significance (2-tailed)	.736	.006	.610	.
		df	307	307	307	0

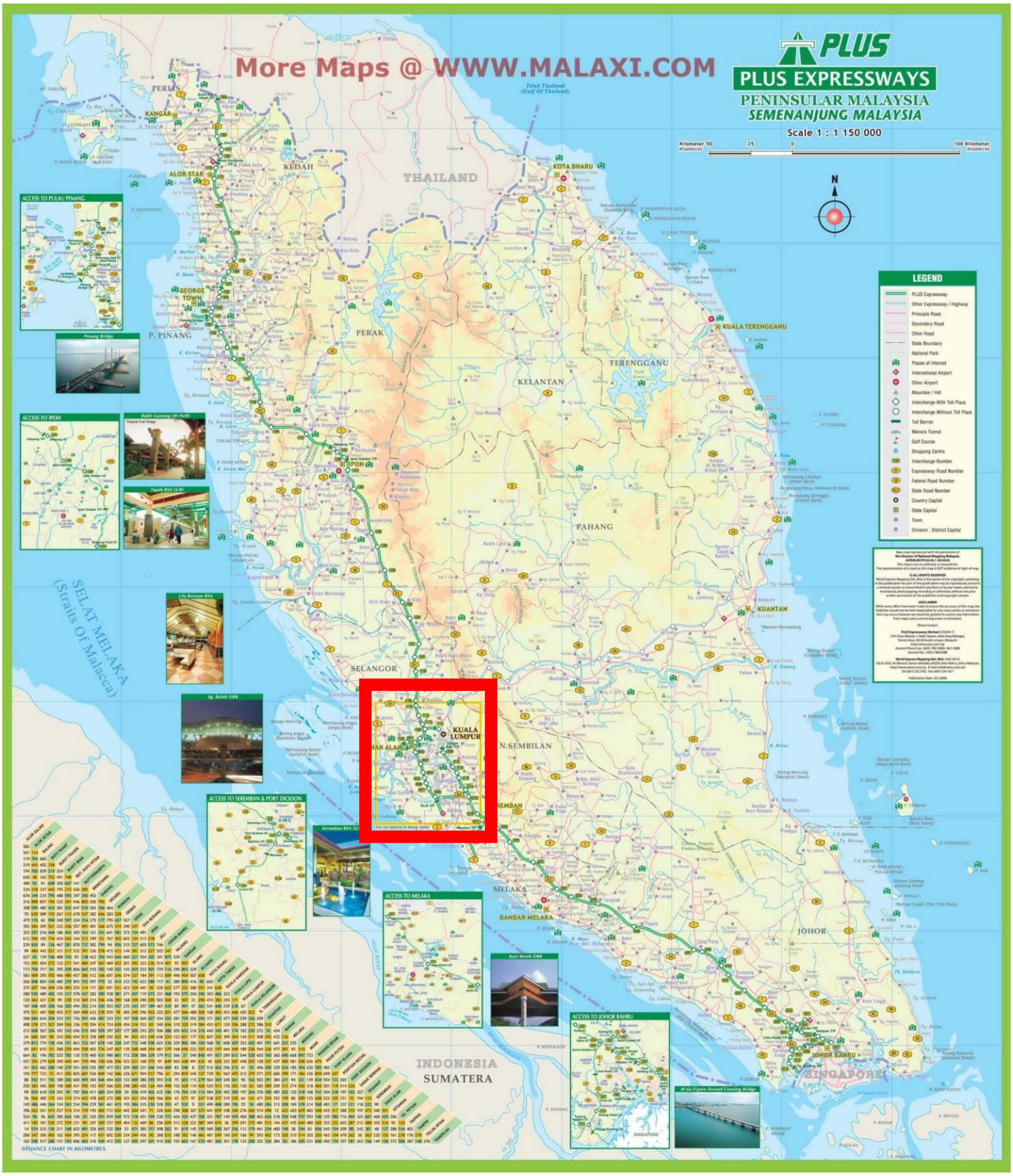

Figure 1: Location of Klang Valley, Malaysia shown in read pane

(http://www.malaxi.com/highway_express/images/plus_expressways_map.jpg)