

Article

## Evaluating Defect Reporting in New Residential Buildings in New Zealand

Funmilayo Egun Rotimi <sup>1,\*</sup>, John Tookey <sup>2</sup> and James Olabode Rotimi <sup>2</sup>

<sup>1</sup> University Admissions, Auckland University of Technology, Auckland 1010, New Zealand

<sup>2</sup> Construction Management Programme, Auckland University of Technology, Auckland 1010, New Zealand; E-Mails: jtookey@aut.ac.nz (J.T.); jrotimi@aut.ac.nz (J.O.R.)

\* Author to whom correspondence should be addressed; E-Mail: frotim@aut.ac.nz; Tel.: +64-9-921-9999 (ext. 6850).

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**Abstract:** The need for defect reporting is becoming increasingly difficult to ignore at handover of new residential buildings. A general review in defect studies has consistently shown that newly built properties can be found to have a significant number of defects. Very often the responsibility for rectifying these common defects is borne by the new homeowner even though house developers are liable. In the current study, survey data is obtained from 216 recent home purchasers/owners across New Zealand urban cities. The intent of the investigation is to show that opportunities exist for defect reporting that will act as a mechanism to measure performance and thus improve the quality of finished construction products in New Zealand. The study found that a significant number (81%) of the participants were involved in the construction of their homes and could influence quality performance if they were proactive enough. The results show that (64.7%) did not engage the service of independent building inspectors for defect reporting on their new homes. Seventy-four percent now agree that independent building inspection was important in hindsight. The study findings are in line with literature on defects and the poor use of defect reporting in new residential buildings. The current challenge for defect rectification by house developers after handover is real and this could increase the confidence that new home owners can have in their developers. Defect reporting could confer benefits to new residential building quality in New Zealand and should be embraced as part of a wider best practice.

**Keywords:** defects; defect reporting; residential buildings; New Zealand

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## 1. Introduction

There is sufficient evidence to suggest that the numbers of defects in new residential buildings are significant and demand attention. Their occurrences have dire consequences on construction project parties and end-users, and contribute to generally low reputation for quality achievement within the housing sectors of most countries. Defects are a problem within the UK construction industry [1–3] and in Australia, the severity of non-quality achievement are illustrated in several studies [4–6]. A more recent study in Spain confirms that defects are evident at post-handover stage of buildings within its housing sector as well [7]. These and similar studies confirm that defects in residential buildings deserve attention and the costs to rectify these defects are enormous. New residential buildings in New Zealand are not an exception with its history of weather tightness problems.

Literature shows that high quality builds cannot always be achieved by relying on the performance of construction parties [1]. Hence a firm process for defect identification and rectification that are needed to put home owners mind at ease about the final quality of their investments. Considering also that seeking redress and identifying accountability is difficult when quality issues arise in residential buildings [8]. Bates and Kane [9] explain that quality failure is attributable to a significant lack of understanding of the fundamentals of good building practices that occur at every stage of the design and build process; from designers, to builders, to inspectors and so on. These poor understanding are considered highly noteworthy within the general construction industry.

Defect reporting refers to the process of checking for faults or defects in a property and rectifying them. It is generally advised that defect reporting be undertaken before a property is handed over to a new owner, because it might be a missed opportunity for the owner to ensure their rectification. An alternate word for defect reporting is “snagging” or building inspection [10]. However for the purpose of the current study the words “defect reporting” and “building inspection” will be used.

Measures and processes need to be put in place that encourage defect reporting so that opportunities where improvements could be made to forestall defects in building construction can be identified. Craig [1] identified two useful opportunity points where building inspection processes could be enhanced for overall building construction performance. The first opportunity point is during construction work when “absorbed defects” are identified by the builder or Council inspectors. Absorbed defects are the defective items that occur during the actual building construction process [1]. If proper attention is paid to performance details, these “absorbed defects” may be rectified before practical completion of construction works. The second opportunity point for building inspection is at hand-over of newly constructed buildings to new owners. Defects identified at this stage are referred to as “visible defects” [1]. Visible defects are those which are usually detected by home owners after occupation. These are the category of defects that become burdensome to home owners because often, absorbed defects would have been rectified when seeking building compliance certification.

Defect reporting as a building production process has not been as widely adopted for new residential house buildings in New Zealand [11]. Further, a review of literature on the subject matter

shows an absence of related New Zealand research and therefore a knowledge gap exists which the current study addresses. The study's premise is that there are benefits to defect reporting for new buildings which the New Zealand building production process should embrace for best practice. Defect reporting before or after handover should enable house developers to rectify potential defects before they become burdens for home owners. Ultimately this should increase the confidence that new home owners can have in their developers and the quality of their new homes.

## 2. Literature Review

### 2.1. Defects and the New Residential Building

Research works undertaken in the UK residential sector provide basis for similar studies in New Zealand. The UK experience is that low quality performances are prevalent in new residential buildings [12]. Earlier research by Sommerville *et al.* [10] on 600 new residential buildings in the UK, found in a typical five bedroom house, a staggering record of 406 visible defects. Sommerville and McCosh [3] also studied 1700 new homes in the UK, over a period of 40 months, and found a significant number of visible defects across all buildings inspected. The worst case recorded found 389 defects in a single property. Sommerville and Craig [12] analyzed more data on 2202 new buildings over a period of four years. An approximate 130,000 defective items were recorded, with 68% of the defects being attributable to poor workmanship and 14% due to omission. Craig [1] followed up with longitudinal data (2002–2006) on 3696 new residential buildings, showing that an overall industry average of 53 visible defects per new home was eminent in the UK. Craig's study was the first step towards providing a benchmark figure for the house building sector in the UK.

Defects in new residential buildings in Australia are not any different from the UK. For example, Georgiou [4] analyzed 1772 houses between 1988 and 1996, of which 1002 were houses built by their owners and 770 by registered builders. Two-thousand, seven-hundred and forty defects were recorded with about 2% classified as major. Sixty percent of the defects were technical in nature such as cracking, dampness and structural inadequacy. Thirty-eight percent of the defects items were attributed to workmanship. In that study, defect numbers ranged from 0 to 21 per building and many had numerous incomplete items despite the issuance of occupancy certificates. More recently a study conducted by Mills *et al.* [6] on the cost of defects in new houses in the state of Victoria, Australia from 1982 to 1997 used a subset of approximately 32,000 records. The results of the analysis reveal that one out of eight buildings was reported to have defects and the estimated cost to rectify these defects was 4% of the construction contract value. In Malaysia, Fauzi, Yusof and Abidin [13] evaluated housing defects on recently implemented Build-Then-Sell (BTS) houses. The study reveals that the BTS housing delivery system was proven to record low defects in houses. However, though most of the houses recorded low defects, there were cases where the workmanship and the materials used by certain BTS developers were unsatisfactory. The severity of non-quality achievement was illustrated in similar studies in Spain. Forcada, Macarulla and Love [14] examined residential defects at post-handover of new residential buildings. A total of 2351 post-handover defects were derived from four Spanish builders in seven residential developments.

In New Zealand, Page [15] identified some defects during a pilot study of new house owners. Page's study was aimed at monitoring call backs, as an indicator of construction quality. The result of the study found that a significant number of new homes (72%) require defects rectification, suggesting that improvements were needed to work performance by home builders. The current study extends Page's pilot work with a view to providing more detailed data on the nature of these defects.

The general review of defects in this section has shown that newly built properties could have significant number of defects [3]. Craig [1] concludes that new homes are repeatedly handed over to new home owners with very high levels of defects which cause those owners to be dissatisfied with the overall quality. Although these studies used data from different sources such as independent building inspection reports, questionnaires to home owners and archival records, what is common is that defects were apparent. These defects were found after the properties had been checked, verified and passed over by the house building developer to home owners. Sommerville *et al.* [10] explains that home owners of the properties surveyed had identified between 20 and 30 defects on their own before independent building inspections were carried out. With these numerous quality problems in residential construction, the current study shares the view that high quality builds cannot always be achieved by relying on the performance of construction parties [1]. The occurrence of defects is an indication that the desired quality of a completed building has not been achieved and these result in rework. Therefore the need to meet home owners' expectations of quality and consequently improve industry best practice cannot be overemphasized.

## 2.2. The House Buying Process in New Zealand

The house buying process in New Zealand such as in any other country has a number of stakeholders. These include house buyers (owners), house developers, council inspectors, independent building inspector and financiers. These stakeholders have differing roles and priorities regarding quality expectations and performances. House owners are very often more concerned with aesthetics and functioning of their building properties. House developers on the other hand, perform to meet set standards (such as those contained in building regulations, drawings and specifications) [1]. Council inspectors focus more on technical quality aspects of buildings and would aim to monitor developers' performance so that they meet codes and regulatory requirements. Council inspectors in New Zealand carryout a range of inspections depending on the inspection stages contained in consent documents. Independent building inspectors' complement council inspectors by acting on behalf of home owners to ensure that their concerns are addressed during the house buying process. Finally, the financiers, as stakeholders provide necessary funds to carry out building works, either to the house developers or home owners.

There are three common ways by which new houses are purchased in New Zealand. The first is to buy a completed building that has been built by a house developer who may or may not be professionally registered. The process begins with the customer visiting the new home on a particular site. This is the only indication to a customer of the quality and standard that they may expect to receive. This is speculative, since decisions on purchase of land, building design and building production are made without any reference to the prospective home owner, who is often found after the building has been built [16,17]. Speculative house builders buy and trade in land, they then build and

sell these completed houses. It is difficult but not impossible for house buyers to order the house they want, though there could be minor modifications to the standard [18]. In this buying process, quality requirements rest on the developer.

Another way by which new houses are purchased is by negotiating and buying a house that is under construction. In this case, the buyer enters an agreement to purchase the house upon completion. In this process, the potential home owner could make changes to the building, depending on the construction stage. Defects or quality failures could be identified during construction by the home owner during visits to the site and may be rectified at the insistence of the potential owner. The identification of defects will depend on the level of building construction knowledge of the owner.

Finally, the house buying process may be by purchasing what is referred to as a complete land package from a developer. The designs may be bespoke, using the owners' own designers or from prototypes offered by the developer. Management of the construction could be by the designer (on behalf of the owner) or by the developer. Alternatively, an owner provides the land and the house builder constructs and often provides the design service. This house procurement type takes significant risks away from the developer [19]. This is a non-speculative house buying process, which means that home owners are more involved in the construction of the buildings. Early involvement of the new homeowner in this process may allow for quality performance and satisfaction to be achieved.

Georgiou *et al.* [20] believe that the perceived level of expected product quality varies with the different house procurement approaches. Although whichever the process through which a home is purchased or built, it is important that the quality needs of the owners are met. Ong [21] encourages potential home buyers to buy a home that is not yet built because this makes a lot of difference compared to buying an existing new home. This way the chances of taking short cuts or making mistakes by developers may be reduced. Generally the more the checks on building performance, the more probable the final build will meet the required quality standards. Holder [22] suggests that home owners have a responsibility to ensure that their needs are met. Holder advocates professional quality audits (defect reporting) to enable the identification of defects that may not be visually detectable and for which ordinary reports or inspections may not highlight. In the same light Landin [23] suggests defect reporting for ensuring quality achievement, even though it occurs downstream within the house buying process.

### 2.3. Inspection Regime in the House Building Process

In New Zealand and most regulated economies, it is a requirement that a building consent is granted by an approving authority (Building Consent Authority) before the commencement of construction work. The role of the Building Consent Authority is to review and inspect work and processes to ensure that the proposed and completed building complies with performance requirements as specified in Building Codes. This offers protection to current and future owners [9,24]. The Building Codes and regulations are supported by a self-regulated inspection reporting system, all of which are routinely checked by council building inspectors [6].

Building inspection is usually carried out at specific stages corresponding to building progress and based on the submitted plans and specifications. Work could only proceed upon certification that each stage of construction work is satisfactory and complies with consent documentation. However, Council

inspectors are not clerk of works and do not provide full inspection or quality control services [24]. The inspection regime concludes with a final inspection of the completed build after which a Code Compliance Certificate (CCC) is issued in New Zealand. House sales and purchase contracts are often conditional on the issuance of a CCC in New Zealand [25]. This assumes that staged council inspections during construction could have identified defective work, and which would have been rectified before the issuance of a CCC. Home owners would normally assume that most defects have been taken care of through this building inspection process and may not see a need for further inspection work. Thus, the overall quality of the finished product is often overlooked during the buying process, but once a buyer has moved in, perceived problems can grow out of proportion to affect the overall performance of new buildings.

As was previously explained, the focus of the current study is on the evaluation of defect reporting (especially visible defects that arise after CCCs have been issued) and how this impacts on quality performance. It is established that defects that occur after practical completion have been regarded as causes of conflict and distress to parties involved in the house building/buying process. It seems rational to want to suggest that defect reporting is pertinent in residential building construction. Sommerville *et al.* [2] explain that purchasers of new homes that are defective cannot just “give it back” and may not be able to request a refund in most cases. Thus, encouraging defect reporting within the house buying process may be a preventative approach to quality non-achievement.

### 3. The Research Approach

The objective of this study is to determine the level of use of independent building inspections (as a proxy for defect reporting) at hand over of new residential buildings in New Zealand. This way the body of knowledge around defects and defect reporting is enhanced in New Zealand. As a consequence the quality levels of new residential homes are enhanced and home owners could have increased confidence in their developers and the construction industry generally.

To achieve this, new home owners are the populations considered for the study. The total population was determined from a database of building consent application records for the period 2008 to 2011. The study sample frame was determined using the formula for sample size determination [26]. The sample size was subsequently reduced to buildings with site addresses that were post coded, with only single dwelling consents. A semi-structured questionnaire was then administered (via post) using a random sampling method in order to provide an unbiased subset of the population [27]. Random numbers for the study participants was generated using MS Excel from a database of new home owners in New Zealand, during the period 2008 to 2011. The initial data search yielded 34,000 new dwellings within 67 territorial authorities. Consequently a total sample size of 1032 across 34 territorial authorities was obtained. However, the total number of usable questionnaires obtained was 216, representing an overall response rate of about 21%.

A quantitative approach was adopted for data analysis in order to achieve the set study outcomes. Both descriptive and statistical analyses were employed. Descriptive analysis could be classified under quantitative research and is concerned with information generally obtained by interviews and mailed questionnaires [28]. O’Leary [29] explains that statistical analysis could be descriptive (to summarize the data), or inferential (to draw conclusions that extend beyond the immediate data), statistical analysis.

Cross tabulation of some of the results is undertaken to provide a basic picture of the interrelations between two variables, so that the interactions between them can be understood. The analysis of the data took place via coded entry into SPSS and Excel as appropriate.

#### 4. Data Analysis and Discussion of Results

##### 4.1. Demographic Information

Table 1 provides a summary of the demographic information obtained from 216 study participants. There were four related questions covering: type of ownership, period of ownership, building category, and information on the house developer involved in the house construction. Table 1 shows that majority of the study participants own their homes (98.6%) with only (1.4%) under a rental agreement. As the target population for this study is residential home owners, this result is in line with the study objective. Information obtained on the period of ownership show that the majority of participants (73%) have owned their homes for less than two years, compared to participants who indicated that they have owned their homes for over two years (27%). The desire of the study was to target recent home owners so that their opinions on defects will not be biased by any observed maintenance-related defects.

**Table 1.** Participants' demographic information.

Profile of respondents		Frequency	Percentages
Types of ownership	Homeowner	213	98.6
	Renting	3	1.4
Period of ownership	>4 weeks	6	2.8
	1–6 months	25	11.6
	6 months–1 year	31	14.4
	1–2 years	95	44.2
	>2 years	58	27
Building category	House	204	94
	Townhouse	10	5
	Apartment	0	0
	Unit	1	0.5
	Retirement village	1	0.5
Who built the house	Developer (Master builder)	135	62.8
	Developer (Certified builder)	31	14.4
	Yourself	17	8
	Private developer	24	11
	Do not know	8	4

The third set of demographic information provides an understanding of house-type-related disparities, in nature and number of defects. Majority of the participants (94%) fell into the single-lease house category, meaning the buildings were single family dwellings. Five percent of the participants owned town houses (shared-lease), while 0.5% of participants owned units and retirement villages respectively. The last demographic information comprises the type of house developers that built these homes.

The last question in this section was intended to show the quality performance of different types of house builders and their responses to rectifying defects. 62.8% of the participants indicated that their houses were built by registered Master Builders and 14.4% by certified builders. Eleven percent of participants had their houses built by private house developers while 8% of the participants built their own homes. Only 4% of the participants indicated that they do not know who built their houses, most likely indicating that they were not involved in the building process. The demographic information suggests that the survey covered the population targeted for the study and results reliably depicts the levels of usage of defect reporting in residential buildings in New Zealand.

#### 4.2. Defects in New Residential Buildings

This section of the questionnaire required study participants to indicate the types of defects that they observed when they took possession of their new homes. Study participants were provided a 43 standard term common defects in residential homes checklist. These had been extracted from previous literature on defects. Study participants were able to add other observed defects different from the ones provided in the questionnaire. Eighty-one percent confirmed the existence of defects at the time of handover, while 19% indicated their homes were defect free. Study participants confirmed 42 of the defects with 13 additional defects identified. A frequency chart showing the different defects identified in new homes is presented in Figure 1. From Figure 1, the 10 most common defects in order are: uneven painting surfaces, nail pops, poor finishes, poor flooring, poorly fixed door and window handles, poorly installed kitchen units, building cracks, poorly fixed toilet/WC, concreting and locks.

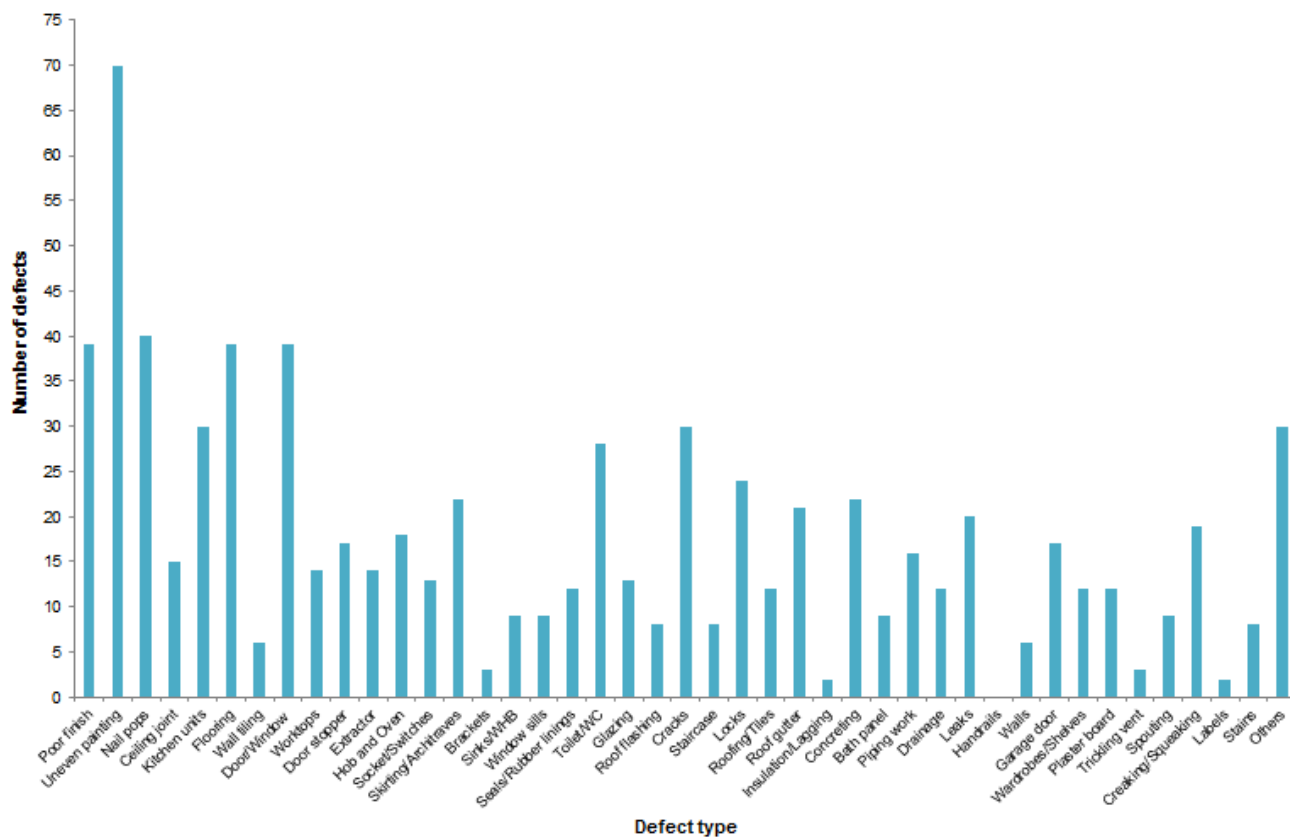
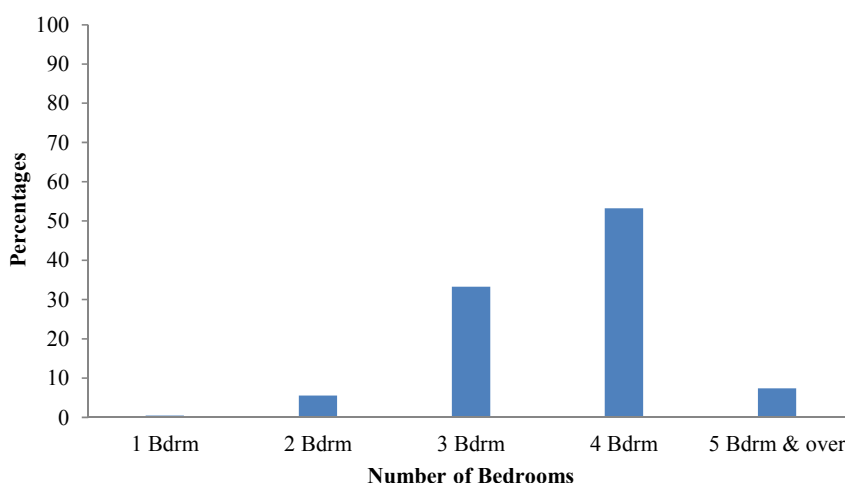


Figure 1. Common defects observed in new residential buildings.



Further, the study observed the distribution of the identified defects across 216 new residential buildings. The defects were grouped into 4 categories: 0–5, 6–10, 11–15, and 16–20, respectively. This permitted the determination of the total number of defects in each property type (from one to five-bedroom and over homes). Seven-hundred fifty-two defects were listed across the survey for the period 2008 to 2011. The result is presented in bar chart form in Figure 2 and depicts defect numbers being directly proportional to the number of bedrooms in the house. Thus, as the number of bedrooms in the houses increase, there is an increase in total number of defects. This excludes over five bedroom homes where the total number of defects is relatively small. Although it might have been expected and indeed logical to expect an increase in quality achievement as the number of defects decreases, the full extent of this increase was not expected. The current finding is in line with Craig's [1] study indicating that there is a strong positive correlation between defects and numbers of bedrooms in residential buildings.



**Figure 2.** Distribution of defects per number of bedrooms.

#### 4.3. Defects Reporting in New Residential Buildings

A key objective of the study is to determine the opportunities for defect reporting by establishing the quality aspects that are lacking within the current house buying process. A summary of the questions asked and the corresponding responses (frequency and percentages) is provided in Table 2.

The first question required participants to indicate when they became involved in the buying process of their homes. The result shows that a significant number (81%) of the participants were involved during the construction stage, followed by 15% of when the buildings had been completed. The smallest percentage (3%) had been involved since the design stages. From the result it can be ascertained that most home owners questioned were involved during the design and construction of their new homes. It could be argued therefore that these home owners have the potential to influence the developers' quality performance. For the few who became involved after completion, it can be argued that they had little or no influence on quality performance.

**Table 2.** Summary of responses to survey questions.

Nr	Questions asked	Response options	Frequency	Percentages
1	Stage at which participants' became involved in construction ( $n = 206$ )	Beginning of construction	174	81
		During construction	7	3
		After completion	32	15
2	Extent of defects noticed after possession ( $n = 178$ )	Very high	4	1.9
		High	10	4.7
		Average	31	14.4
		Low	17	7.9
3	Was developer notified of defects? ( $n = 180$ )	Very low	116	54.0
		No	14	6.5
		Yes	165	76.7
		Unsure	1	5
4	How much of defect was rectified? ( $n = 171$ )	0%–20%	27	12.6
		20%–40%	6	2.8
		40%–60%	16	7.4
		60%–80%	25	11.6
		80%–100%	97	45.1
5	Use of independent building inspection ( $n = 205$ )	Yes	58	27.0
		No	139	64.7
		Unsure	8	3.7
6	Usefulness of building inspection reports ( $n = 186$ )	Very useful	27	12.6
		Moderately useful	16	7.4
		Slightly useful	7	3.3
		Neutral	20	9.3
		Slightly not useful	3	1.4
		Moderately not useful	1	0.5
		Very not useful	5	2.3
N/A	107	49.8		
7	Likelihood of using building inspectors for new homes ( $n = 192$ )	Most likely	53	24.7
		Likely	22	10.2
		Neutral	20	9.3
		Not likely	18	8.4
		Most likely not	15	7.0
		N/A	64	29.8
8	Necessity for building inspection at handover ( $n = 205$ )	Completely agree	113	52.6
		Mostly agree	28	13.0
		Slightly agree	11	5.1
		Neutral	4	1.9
		Slightly disagree	1	0.5
		Mostly disagree	1	0.5
		Completely disagree	0	0
N/A	35	16.3		

The next question required participants to indicate on a Likert scale the extent of defects they observed when they took possession of their new homes. One-hundred seventy-eight participants responded to this question with about 62% indicating that they observed low levels of defects in their homes after handover. Only 6.6% observed high defects, with 14.4% revealing that they have “average levels” of defects. Of the 62% of participants who indicated that they have low levels of defects, 87% had very low defects levels. Overall, the result shows that the participants that responded to this question had identified some form of defects which needed to be rectified. It is important to note the subjectivity of this question, meaning that the definition of each term used in the Likert scale can be defined differently by each participant. It is, therefore, possible that their perspectives are relatively ignorant as compared to the perspective of a suitably trained building inspector, for instance.

Study participants were asked if they informed their house developers when they noticed defects in their homes. 16.3% of the study participants did not attempt this question and out of the 83.7% ( $n = 180$ ) of the participants that responded, 76.7% indicated that their developers were notified when the defects were observed.

Only 6.5% of the participants stated that they did not notify their developers when they noticed defects in their homes. 0.5% was unsure as to whether or not their developers have been notified. The result suggests that there is a loose requirement for house developers to rectify defects once buildings have been handed over. However, a significant percentage (80%–100%) of defects that were notified were rectified in 45.1% of the cases. Another 12.6% of the participants indicated that less than 20% of the defects they observed were rectified by their house developers. It shows that 23.7% of homeowners had less than 60% of defects rectified. Meaning 1 in every 5 had about 40% of their defects not rectified. This will suggest that defects are never completely rectified because relatively more percentages of defects are partly rectified.

#### *4.4. Independent Building Inspection*

The next set of four questions sought home owners’ views on the use of independent building inspections in new homes in New Zealand. The questions cover the use of independent building inspector, usefulness of the report obtained from independent building inspection, likelihood for using building inspectors for new homes, and their opinions about having new buildings inspected for defects before possession. The objective of the questions is to determine the proportion of new home owners that commission the services of independent building inspectors (defect reporting) and also in what circumstance(s) individual home owners would be likely to carry out inspection on new buildings. Majority of the participants (64.7%) did not engage the service of an independent building inspector when they purchased their new homes. Only 27% had building inspection work carried out. From the result presented in Table 1, the majority of the participants (62.8%) and 14.4% had their homes built by master builders and certified builders respectively. It can be assumed that these owners could not see the need for building inspection considering that the houses were built by master builders and certified builders. These categories of developers are certified builders and are therefore able to provide building warranties as a protection against defects when they arise. It could be argued that since majority of home owners (81%) were involved at an earlier stage during the construction of their buildings, they may not realize the need for defect reporting.

From the few participants who engaged the service of building inspectors, their opinion was sought on the usefulness of the report they received after the inspection. It was indicated by 12.6% that the inspection report was very useful with 9.3% of the participants showing a neutral position. Of participants, 7.4% found the report from independent building inspectors to be moderately useful, 3.3% indicated that it is slightly useful, while 2.3% indicated not very useful. It is apparent from this result that a significant proportion of study participants had not engaged independent building inspectors and of the few that did, the usefulness of such reports is evident. Out of the 27% of participants that commissioned defect reporting for their new homes, 23.3% (one end of the scale) of them found the reports to be useful.

The next question required participants to signify their likelihood to engage the service of independent building inspectors for future new homes. The result shows that about 35% of participants are likely to engage an independent inspector to inspect their future new homes, while only 15.4% are not likely to have their future new buildings inspected. Of the participants, 9.3% are neutral, meaning they are likely or not likely to use an independent building inspector for future new homes. This result suggests that the high number of participants willing to have their future buildings checked and inspected could have responded positively because of their previous experiences with defect rectification with their house developers on their current properties.

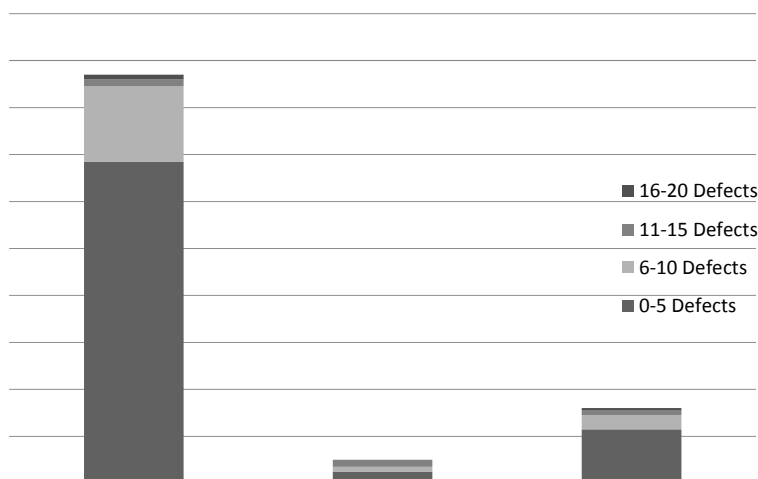
The last question required participants to indicate whether they agree to the idea of having new residential buildings checked for defects by an independent building inspector at handover. The purpose of this question is to confirm whether home owners have seen the need for defect reporting in new homes. From the result, it is obvious that over 70% of participants agree to have an independent building inspector to inspect their homes at handover, with 74% of those in agreement indicating that it is a very good idea. Only 1% of participants believed that building inspection is not necessary at handover, and of these, none completely disagreed with the idea of building inspection. The possibility of ignorance to the benefits of building inspection (defect reporting) for new homes cannot be discounted, hence the need for creating awareness to this fact.

As a further analysis, cross tabulation of some of the information provided in Table 2 was undertaken. The first cross tabulation provides some confirmation of the influence that home owners could have on quality performance of house developers at stages during the production of buildings. Figure 3 presents the cross tabulation between the stage of involvement of home owners during building construction and the number of defects observed in the form of a stacked column histogram. Concentrating on defects ranging from 0 to 5, the result shows that home owners who were involved from the beginning of their buildings appear to find the most number of defects (63.4%) in this category. One would expect this category to have the most influence on quality performance as most defects could have been identified and corrected during building construction.

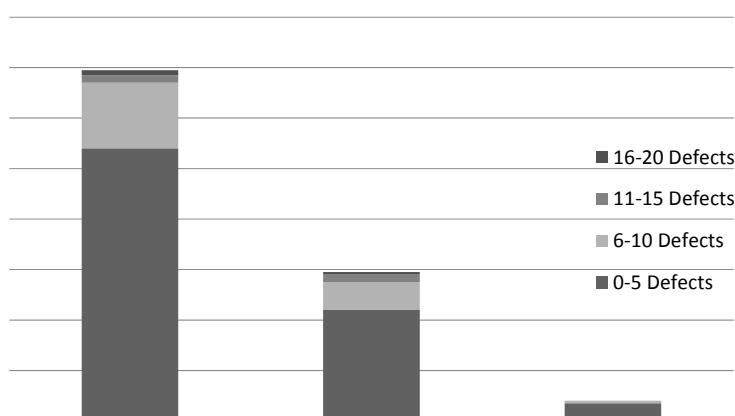
A reason for this result may be that this category of home owners have become very observant, from continuously going through their building project while construction work progressed. Conversely participants who became involved later, during the construction of their homes observed the least (2.3%), 0 to 5 defects. However, participants who became involved after their buildings were completed, comparatively observed more defects than the former category.

The second cross tabulation was on the relationship between participants' engagement of the service of independent building inspectors and the number of defects noticed in new homes. The cross

tabulation is presented in Figure 4 as a stacked column histogram and shows that all the participants who engaged the service of building inspectors (14.3%) found about 20 defects in their new homes. Whereas those participants that did not engage the service of building inspectors found defects ranging from 5 to 20, but with a greater percentage (42.9%) identifying only 5 to 10 defects. It seems from this result that the high number of defects recorded by the participants that engaged building inspectors was as a result of the professional services rendered by these inspectors. This seems plausible when one assumes that home owners may not have sufficient expertise to identify defects as they rely on visual inspections as opposed to thorough checks that could be more effectively carried out by professionals.



**Figure 3.** Home owners' stage of involvement and number of defects.



**Figure 4.** The use of independent building inspectors and number of defects.

## 5. Discussion

The study investigation generated a list of common defects and provides insight into the extent of defects experienced by new homeowners at handover. Ten common defects were identified in this study. These include: uneven painting surfaces, nail pops, poor finishes, poor flooring, poorly fixed door and window handles, poorly installed kitchen units, building cracks, poorly fixed toilet/WC, and locks and concreting. This list of defects was mostly of an aesthetic nature and confirms previous research that had shown that these particular class of defects are the most important to new homeowners, since more technical defects would have been addressed during stages of building compliance

inspections [1,2,15,30]. This information enhances the understanding of quality performance in the residential and wider construction industry in New Zealand. This finding is in agreement with Page's [15] conclusions that defects are prevalent in new residential homes in New Zealand and that a significant percentage (72%) of new homeowners have to call back their developers to rectify these defects.

Further, in support of most existing literature [1,12], this current findings confirm that the use of defect reporting organizations (independent building inspectors) for new residential buildings are generally low in New Zealand. Inspection and defect reporting is predominantly undertaken for older and existing buildings. However, home owners who used a defect reporting organization identified more defects in their homes. This seems reasonable when one considers that home owners are unlikely to have sufficient expertise to identify defects because they rely on visual inspections as opposed to the more thorough checks that could be carried out by independent building inspectors.

Defect reporting has been suggested as a viable solution to identifying defects in new homes before they are handed over to their owners [11,14]. Examining the findings in this study, two possible explanations become evident. Firstly, the possibility of ignorance of the benefits associated with the use of independent building inspection (defect reporting) for new homes cannot be discounted. Secondly, is that there is naivety on the part of homeowners', especially first time owners, who consider that avoiding such inspections are a "cost saving" measure. The current study takes the position that getting new buildings checked and corrected for defects as soon as they are identified, is one way of ensuring customer satisfaction and consequently ensuring industry best quality practice. While council inspection and house developers may focus on technical aspects during construction progress, defect reporting organizations are able to look at both the technical and functional aspects of quality. The study therefore finds benefits in using independent building inspectors in new residential buildings in New Zealand.

## 6. Concluding Statement

This paper has as its objective the determination of the level of use of independent building inspections (to explain defect reporting) at hand over of new residential buildings in New Zealand. The determination involved a questionnaire survey administered to new homeowners within five regions in New Zealand. The study findings show that the engagement of the services of independent building inspectors for new buildings is low compared to old and existing buildings. The house buying process seems to favor building inspection for older building stock. The current study provides evidence to suggest that a significantly higher number of defects can be detected by professional building inspectors. This should serve as an encouragement for engaging professional defect reporting services. This is an invaluable insight into an obvious lack of awareness, thus opportunities exist for defect reporting (building inspection) in New Zealand.

Home owners are at a disadvantage when quality problems arise in their new residential buildings. These become burdensome and even though house developers are liable to rectify some of the visible defects in new homes, getting them to fix the problem could be challenging. The authors believe that no matter the stage at which home owners become involved in the residential building process, it is important that inspection and quality control be carried out on these buildings. Such practice will aid the overall quality process in residential buildings. Therefore opportunities exist for defect reporting

post-handover that could act as a mechanism for performance measurement and thus improve the quality of finished construction products. The benefits outweigh any expenditure that may be involved. The more the checks and defect reporting on building performance, the more probable it will be that defects identified will be within normal limits.

The search for quality improvement in the residential sector is driven by a long list of industry wide problems, such as poor inspection processes, poor workmanship, unskilled workers, and unreliable defect documentation. The absence of records on defects at handover of new residential buildings in New Zealand existed before this study, thus the one obvious benefit is the establishment of a database comprising whatever data can be gathered from existing sources. This database can then be compared with studies in other countries. This in turn will provide a benchmark for future performance improvement within the residential sector in New Zealand. Thus, a firm process for defect identification and rectification should put home owners' minds at ease about the final quality of their investments.

Further research is required to investigate the financial implication of defects identified at handover of new residential buildings. This will enable an understanding of the severity of the problem of defects on the performance of house developer organization, and consequently on the productivity of the construction industry. At present, an accurate estimate of the financial impact of defects does not exist in New Zealand. An estimating model that can accurately calculate the cost of defects to both the house building sector and the wider construction industry would be beneficial.

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### **Author Contributions**

The paper is based on Funmilayo Rotimi's PhD research work. Funmilayo was responsible for the research design, data collection and analyses. James Rotimi and John Tookey provided guidance and supervision respectively. James Rotimi provided additional insights.

### **Conflicts of Interest**

The authors declare no conflict of interest.

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