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## Diagnosis and Evaluation of Defects Encountered in Newly Constructed Houses in Erbil City, Kurdistan, Iraq

**Abstract-** This study investigated the types and profile of defects facing newly constructed houses through conducting a survey and analyzing defect records of data observed for 652 houses out of 1000 houses newly constructed for Salahaddin University academic staff in Erbil City. The result of analysis revealed that the overall of 6758 defects identified with the mean average of 10 defects per house. The overall percentage of defected houses for each type of defects and the location of the defect ranged from 10% to 67%. The most defected components found in the doors and windows, which comes in rank 1 with the highest percentage of defected houses reached to 76%, whereas coating and painting of doors come in rank 2 with percentage of 75%, and cracks in structural elements come in rank 3 with 73%. Analyzing the defects in terms of area and location showed that the finishing works representing the major defects area of 48%. While, the defects in the doors and window representing second highest defects of 42%. The results indicated that the quality performance in newly constructed houses is low due to poor workmanship and lack of experience and skills of construction staff and inadequate supervision.

**Keywords-** Diagnosis, Defects Evaluation, Erbil City, Newly Constructed, Residential Houses.

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### 1. Introduction

Defective construction refers to works, which not comply with specifications or requirements of the construction contract, especially any drawings or specifications, together with any contractual terms and conditions such as the specified quality, workmanship, durability, aesthetics and the design. Different construction facilities generate different types of defects and demands different levels and types of quality depending on the function, system, types and material used [1].

#### *I. Definition of Construction Defects*

A construction defect is the failure of the building or any element of building erected in a reasonably skillful manner or performed in the manner intended by the builder or reasonably expected by the user [2]. Others defined the construction defect as inconformity of a section or component with standard or specified features. Defect is used sometimes as a synonym for failure, but the preferred meaning is to indicate only a deviation from the specified standard that may, but will not necessarily, result in failure [3].

#### *II. Construction Defect Sources*

The source of construction defects classified in to four general sources of deficiencies comprises, design, material, construction, and the way the building or structure is functioning and as follows [4]:

- 1) Deficiency of Design: Buildings and systems designed by professional do not always work as specified; this can result in the defect. For example, a roof design that allows penetration of water, poor drainage system or inadequate structural support.
- 2) Deficiency of Materials: The use of poor building materials can cause significant problems such as windows that leak or fail to perform even when properly installed.
- 3) Deficiency of Construction: Poor quality and workmanship can result in long lists of defects, like plumbing leaks, damage finishes, and problems in electrical or mechanical installations as well as, cracks in the structure of building i.e. foundations or walls.
- 4) Operation and maintenance: When a construction is completed and a project is handed over to its owner or user, it is a norm that the construction be maintained effectively. Defects, whatever their qualitative natures can be patent or

latent. A patent defect is detectable either at or before apparent practical completion of work or during the defects liability period. By contrast, a latent defect is one that has been concealed in the works and may not be apparent for so many years. The terms latent and patent are opposite. A latent defect will exist before discovered as hidden or concealed flaws in the work [2]. The construction defects can be classified into structural defects and non-structural defects as shown below [2, 5].

### *III. Structural defect*

It means any defect occurred in a structural element (retaining walls, columns, beams, slabs, etc.) of a building that is related to defective design, defective–faulty workmanship, defective material and sometimes any combination of them.

### *IV. Non-structural defect*

It is a defect occurrence in non-structural components of the building because of defective works. It includes defect in the non-structural component of building, electrical and mechanical services, dampness in old buildings, and defects in plaster and finishing works.

## **2. Literature Review**

### *I. Causes of Defects*

Collected information by a researcher on 3000 defects found on site in seven building projects in Sweden showed that the causes were primarily ascribed to the individuals' actions, knowledge, education, motivation. Lack of motivation was found to be the most common and significant cause. Furthermore, 50% of the total defect costs were caused by lack of individual's motivation, and more than 25% of defect costs were due to the lack of knowledge and 12% caused by lack of communications [6].

A study indicated that the failure mechanism that caused by design related latent defects and due to design parameters that could prevent occurrence of these defects. They found that the three most important design related defects causes were; weather impact, occupant's impact, and dampness from the wet elements [7]. Another study examined the factors leading to poor workmanship quality in public building projects using questionnaires forms. Found that these factors were because of poor management, complicated role of subcontractors, lack of experience and competency of workers, lack of communication due to language barrier, unsuitable construction machinery [8]. The causes of construction defects using fault trees and risk importance measures. A study conducted for developing a methodology to identify and quantify the occurrence of risks due

to defective pathways, they applied the methodology to four residential projects in Dubai confirmed that its applicability as an effective tool for analyzing the risk of defect cause in construction [9].

A study revealed that inadequate artisan skills are the major causes leading to the defects in houses, and that cracks are the most frequently occurring. The study also revealed that construction-related causes of defects dominate over design-related causes. The study comprises a list of the causes from highest rank to lowest as follows [10]:

#### 1) Contractor related causes:

Inadequate artisan skills, incompetent contractors, lack of quality management during construction, lack of inspection during construction, lack of management of construction process, inadequate laborer skills, contractor errors, lack of motivation of contractor, defective materials used.

#### 2) Consultant related causes:

Non-compliance with specifications, unqualified designers, lack of communication between designers and contractors, lack of quality management during design, design errors, inappropriate specifications and conflicting details on drawings. During a study conducted on seven schools in Kedah, Malaysia, the contribution of building factors was climatic condition, building age, and maintenance of school buildings, poor workmanship, and insufficient awareness [11].

### *II. Position of Defects*

The defects may occur in any elements of the building, particularly in poorly designed and constructed. Such defects include; cracks in walls especially wherever exists weakness, i.e. windows and doors junctions with extensions, as well as moisture rising in the elements; uneven ground floor slabs, expansion and contraction movement in upper floors; moisture penetration of roof; cracks in plastering [12].

### *III. Area of Defects*

A study showed that wet areas which presents 10% of a building area are contributing between 30% to 50% of the building total repair and maintenance expenditure, and found that defects in building due to the wet areas are mostly attributed to the drying and wetting occurrence in wet areas like bathrooms and kitchens. In addition, the study revealed that the most common type of defected areas, are often accounting for 53% of all the defects studied areas [13]. Another study showed that the defects profile of 327 new houses in the UK in respect to the defects number, type and location mostly related to wet areas such as

kitchens and bathrooms remained as two most significant defective areas, with a high needs for continues maintenance and repair [14].

**IV. Defect Cost**

The cost of the defect is the cost of resources used for repairing the defective work. Various factors are measured as rework time. Time is a lost in waiting and delay because of defects. Defective works not only contributes to the final cost of repairing but also to the cost of maintenance. Defects can affect the success of construction project significantly [1]. Another study focused on defect costs of new houses constructed in Victoria, Australia between 1982 and 1997, revealed that one house out of eight reported defects, and that the cost of rectification was about 4% of the construction contract cost [15]. An earlier study on seven building project monitored during the phase of production showed that the cost of defects corresponds to 4.4% of the production cost. The time to correct the defects was about 7% of the total working time [16].

**V. Defect Liability Period**

Construction contracts are commonly known as a defects liability period agreement. The defects liability period is the specified period of time within which the contractor is contractually obliged to repair all defective works, which have appeared in the project during the period of maintenance. The defects liability period usually commences on practical or substantial completion of the project and extends for a specified period, usually for 12 months. Another study conducted at the Federal University of Technology, Akure, Nigeria.

The study revealed that 6 months defects liability period practice in Nigeria instead of 12 months is not reasonable enough to allow defects to manifest which really poses a major threat to clients and amount to national economic losses [17].

**3. Materials and Methods**

**I. The Study Area**

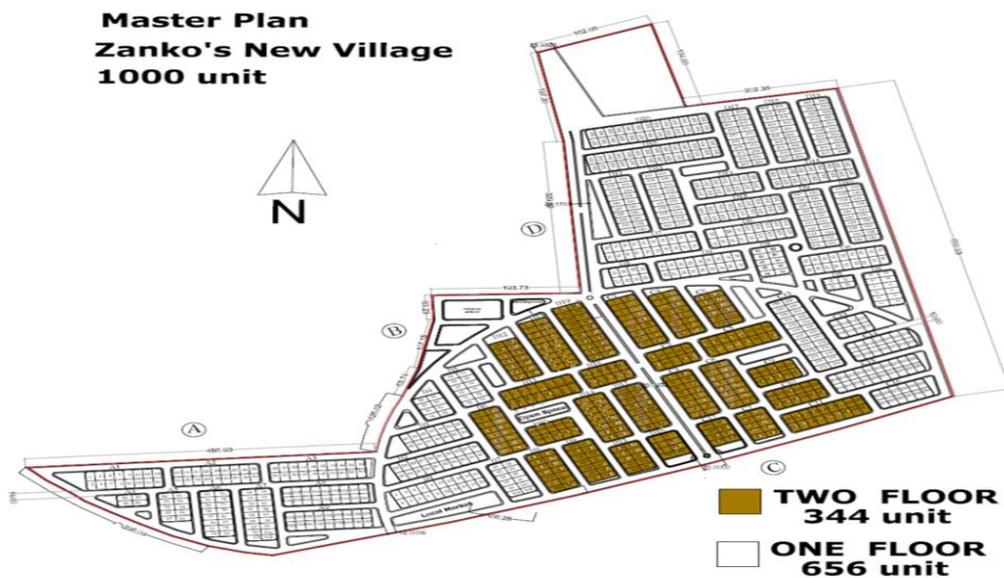
The Zanko’s New Village of 1000 new-built residential houses for the Salahaddin University’s Academic Staff in Erbil city chosen as a case study area. This project carried out by local general contractor from 2009 to 2012. The construction of the project commenced on 1/7/2009 with duration of 915 days (2.5 years). The contract was awarded as a lump-sum contract. The data collected directly after taking-over and before occupation by their owners. The data observed through questions of existing defects; types, locations, areas from archived records of defects of number of surveyed houses was 652 consisting more than 65% of total number of 1000 units. The plot area of each house is 250 m<sup>2</sup>. The mean total built floor area is 148.70 m<sup>2</sup> of one floor distributed in Zones A, C and D, while the houses in 2 floor distributed in Zone B and C with a built area is of 268 m<sup>2</sup> as shown in Table 1. The selling price for one-floor house was \$53200, while for two-floor house was \$83200. Total cost 1000 houses approximately \$63520000 as listed in Table 2. The master plan for Zanko’s New Village of 1000 houses distributed in four zones, A, B, C and D, it is located just behind the College of Engineering, Salahaddin University as illustrated in Figure 1.

**Table 1: Distribution of houses in zones**

Zone	No. of houses	No. of floors	No. of Surveyed houses	% of surveyed houses
A	138	1	98	71
B	268	1 and 2	184	69
C	242	1 and 2	123	51
D	352	1	247	70
Total	1000		652	65.2

**Table 2: Costs Profile of 1000 Houses distributed in Zones**

Zone	No. of houses With one –floor	No. of houses With two- floor	Cost of houses With one-floor \$	Cost of houses With two-floor \$	Total Cost \$
A	138	0	7341600	0	7341600
B	86	182	4575200	15142400	19717600
B					
C	80	162	4256000	13478400	17734400
C					
D	352	0	18726400	0	18726400
Total	656	344	35899200	28620800	63520000



**Figure 1: Master Plan of Zanko's New Village of 1000 Houses for Academic Staff**

#### 4. Data Analysis and Discussion

The current investigation involved sampling and analyzing the collected data of 652 completed questionnaires by conducting a random surveying of 652 houses out of 1000 the analysis of the collected data revealed that a total 6758 defects were identified within surveyed area with a mean average of 10 defects per house. The mean average number of defects per item of defect type were 270 defects. This study found that the highest five records of defective areas were related to the opening of doors, coating (painting) of doors, cracks and broken spaces in the doors and windows, and defects in gypsum plastering as 497, 491, 472, and 424, 404 defects respectively. The detailed defects distributed in terms of numbers of defects and percentages on zones basis as summarized in Table 3.

The statistical analysis for defective houses in Zone A shows that about 85% of houses suffer from cracks in walls and structure elements, 84% of houses with defects of door coating and painting and 6% of houses with defect in the main and sub circuits electrical works. While in Zone B, the percentage of houses with defect of cracks in walls and structure elements reached 68%, opening of doors, handles of doors and windows and door coating are with the same percentages of 71% while 10% of houses with defect of main and sub circuits. The lowest percentage of houses with defects in mixing tapes reached 14%. The records shows that in Zone C, the highest percentage of defects were in the doors and windows functioning, coating and painting of doors at 84% and 80% respectively. Whereas, in Zone D, the

highest percentages of defects are of cracks in the doors, and windows poor functioning is 76% and 75% respectively. The lowest percentage of defects is recorded 7% in the main and sub circuits. Consequently, the highest overall percentage of defected houses is 76% in the doors and windows functioning. Whereas, 75% of the houses suffer from the defect in paint coating of doors, and 73% of the houses having cracks in walls, while only 10% of the houses with defects of main and sub circuits of electrical works. It is worth mentioning that the main reason of recording a low percentage defects in the items of electrical works were due to unavailability of city electricity power to function, test and detect the defects involved in electricity works.

Further analysis was undertaken in terms of ranking 25 components of the defective items as listed in the last column in Table 3. Showing that eleven major defected items recorded more than 50% of the houses, comprised the defected doors and windows comes in rank 1 with the highest percentage of defected houses reached to 76%, whereas coating and painting of doors come in rank 2 with percentage of 75%, and cracks in walls and structure comes in rank 3 with 73%. The eleven significant defective items presented in Figure 2. Despite the relatively high number of defects found in this study, other studies also recorded the significant number of defects. For comparison purposes, it is worth mentioning that a study carried out confirmed 42 of the defective items identified across 216 new residential buildings. Concluding that the 10 most significant defects in ranking order comprise: uneven painting

surfaces, poor finishing works, poor flooring, poorly fixed door and window handles, poorly installed kitchen units, building cracks, poorly fixed toilet, and the number of defects in uneven painting was about to 70% [18].

Furthermore, the analysis of data of current research found that the highest average of 12 defects per house found in Zone C, while the lowest defects per house of 9 recorded in Zone D. Whereas the average defects in Zone A and B were 11 and 10 respectively, as shown in Figure 3.

The data listed in Table 4, shows that the highest percentage of defects appeared in finishing works, doors/windows and handrails totaling more than 90 percent of defects.

Figure 4 represents the overall percentage of defects distributed by area of defects and as follows:

1. Finishing works, comprises stone facing, cement plastering, gypsum plastering, skirts, the coating of doors, flaws in house coating, tying false ceiling with ceiling, wall tiling and ground tiles representing 48%.

2. Site works; they are only marginalization of the garden represent 2%.

3. Defects in the doors and window recording 42%, which include handrail, spaces between windows and wall, spaces around doors and windows using silicon, the opening of doors, spaces in closing doors and windows and main door made.

4. Defects in Electrical works 5%, including fixing of electrical sockets and switches, lights and fans working and main and sub circuits working.

5. Plumbing works such as flushing cistern working and mixing taps working of 3%.

A Similar study carried out, revealed that in 16 areas of defects were identified that the 3209 defects recorded (in 327 new homes). The most two significant areas with highest numbers of defects were in kitchen (479 defects; 14.9%) and in bathrooms (454 defects; 14.1%), external doors (320; 10%), building envelope (287; 8.9%) and in bedroom (235; 7.3%) [14].

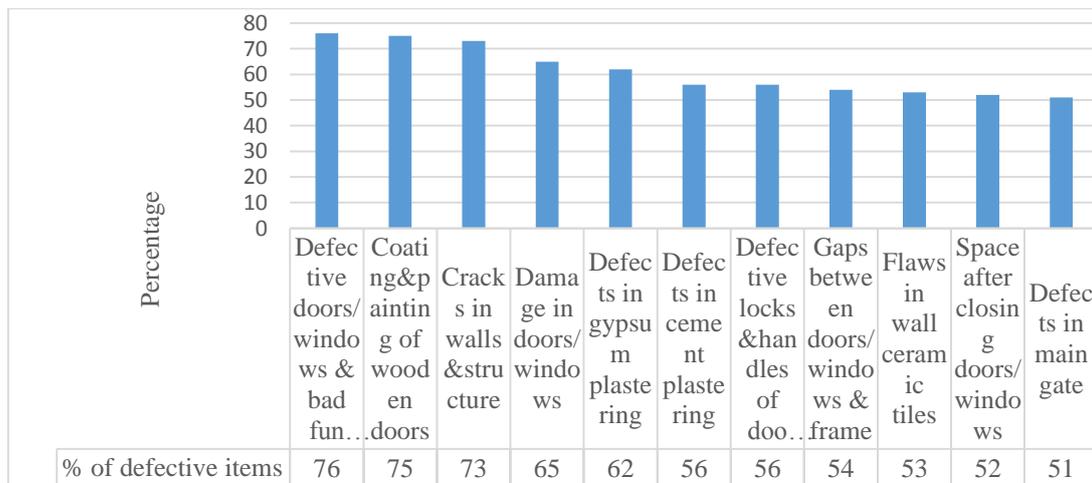


Figure 2: The highest rank of defected items

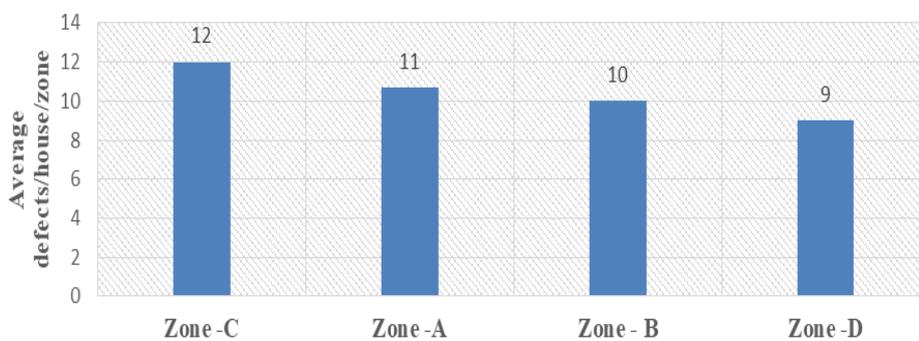


Figure 3: Average number of defects per house per zone

**Table 3: Number of defected houses per zone and percentage of surveyed houses**

Item	Type of defect and location	Zones				Total 652 Houses	Rank
		A 98 Houses	B 184 Houses	C 123 Houses	D 247 Houses		
1	Cracks in walls & structure	83 (85%)	125 (68%)	76 (62%)	188 (76%)	472 (73%)	<u>3</u>
2	Stoppage of water on roof	20 (20%)	50 (27%)	32 (26%)	74 (30%)	176 (27%)	16
3		25 (26%)	40 (22%)	41 (33%)	40 (16%)	146 (23%)	19
4	Flaws in facing stone	56 (57%)	109 (59%)	74 (60%)	128 (52%)	367 (56%)	<u>6</u>
5	The defects in cement plastering	58 (59%)	125 (68%)	75 (61%)	146 (59%)	404 (62%)	<u>5</u>
6	The defects in Gypsum plastering	20 (20%)	52 (28%)	37 (30%)	57 (23%)	166 (25%)	18
7		22 (23%)	52 (28%)	39 (32%)	62 (25%)	175 (27%)	17
8	Defect in ladder handrail	55 (56%)	98 (53%)	71 (58%)	116 (47%)	340 (52%)	<u>10</u>
9	Gaps between door/ windows and walls	61 (62%)	90 (49%)	73 (59%)	94 (38%)	318 (49%)	12
10	Treatment of gaps using silicon is good	63 (64%)	118 (64%)	95 (77%)	148 (60%)	424 (65%)	<u>4</u>
11	Damages in doors or windows	78 (82%)	131 (71%)	103 (84%)	185 (75%)	497 (76%)	<u>1</u>
12	Doors and windows functioning well	52 (53%)	99 (54%)	76 (62%)	126 (51%)	353 (54%)	<u>8</u>
13	No spaces in closing doors and window	70 (71%)	131 (71%)	85 (69%)	82 (33%)	368 (56%)	<u>7</u>
14	Defects in handles& locks of doors & windows	82 (84%)	131 (71%)	98 (80%)	180 (73%)	491 (75%)	<u>2</u>
15	Coating & painting wooden doors is good	19 (19%)	48 (26%)	46 (37%)	67 (27%)	180 (28%)	15
16	Flaws in coating& painting of house	24 (25%)	33 (18%)	25 (20%)	35 (14%)	117 (18%)	22
17	Flushing cistern of closet working well	21 (21%)	25 (14%)	21 (17%)	32 (13%)	99 (15%)	24
18	Water mixing taps working properly	29 (30%)	35 (19%)	41 (33%)	44 (18%)	149 (23%)	20
19	Electrical sockets & switches fixed well	14 (14%)	28 (15%)	31 (25%)	30 (12%)	103 (16%)	23
20	Lights & fans working properly	6 (6%)	18 (10%)	25 (20%)	17 (7%)	66 (10%)	25
21	Electrical main & sub circuits working	48 (49%)	85 (46%)	80 (65%)	106 (43%)	319 (49%)	13
22	Defects in false ceiling	44 (45%)	105 (57%)	65 (53%)	133 (54%)	347 (53%)	<u>9</u>
23	Flaw in wall ceramic tiles	28 (29%)	53 (29%)	43 (35%)	99 (40%)	223 (34%)	14
24	Flaw in ground tiles	14 (14%)	37 (20%)	42 (34%)	32 (13%)	125 (19%)	21
25	Marginalization of the garden lining	56 (57%)	98 (53%)	68 (55%)	111 (45%)	333 (51%)	<u>11</u>
	Defect in main gate						
	Total number of defects	<b>1048</b>	<b>1916</b>	<b>1462</b>	<b>2332</b>	<b>6758</b>	
	Average number of defect per item	<b>42</b>	<b>77</b>	<b>58</b>	<b>93</b>	<b>270</b>	

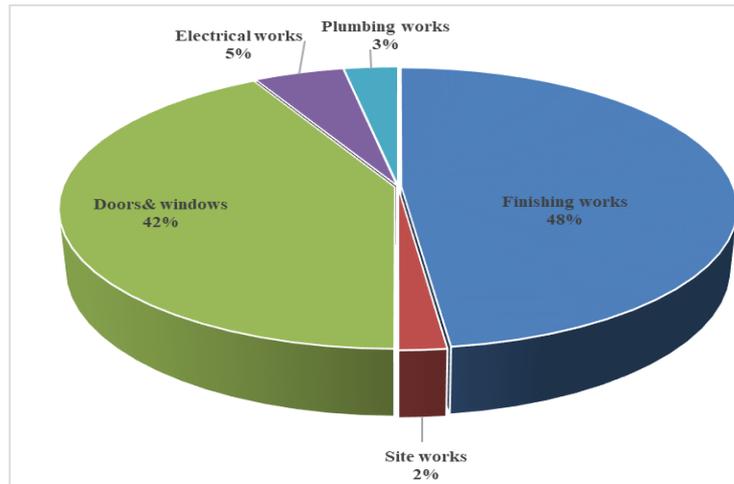


Figure 4: Overall percentage of defects distributed by area of work

Table 4: Defects distribution on the areas of works

Area of Work	Zones				Overall Total
	A	B	C	D	
Finishing Works	483 (46%)	923 (48%)	667 (46%)	1218 (52%)	3291 (48%)
Site Work	14 (1%)	37 (2%)	42 (3%)	32 (1%)	125 (2%)
Doors and Windows & Handrail	457 (44%)	817 (43%)	610 (42%)	924 (40%)	2808 (42%)
Electrical Works	49 (5%)	81 (4%)	97 (7%)	91 (4%)	318 (5%)
Plumbing Works	45 (4%)	58 (3%)	46 (3%)	67 (3%)	216 (3%)

**5. Conclusions**

This paper has examined the defects facing newly constructed houses in Erbil City, and based on the collected data and analysis, hence the following findings conclusions are drawn:

1. The total number of defects found in 652 newly constructed houses covered by the survey reached to 6758 defects representing an overall average of 10 defects per new house.
2. Among 25 types of defects covered by the survey, the most significant eleven types of defects found were; existence of gaps between doors/windows and walls presented 76% of total defective items, coating and painting of doors 75%, damages in the doors and windows reached to 73%. Whereas, defects in gypsum plastering works 65%, defects in cement plastering and defect locks and handle of doors both accounting 56%, gaps between door/window and frame 54%, flaws in wall tiles 53%, space after closing doors and windows 52% and defects in main gate 51%.

3. The average number of defects per house recorded 11, 10, 12 and 9 in zones A, B, C, and D respectively.

4. The overall percentage of defect distributions on areas and locations found that in finishing works presented 48%, whereas in doors and windows recorded 42%, Electrical works only 5%, plumbing works 3% and Site works 2%.

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