

Factors affecting Maintenance of Buildings in Petroleum Training Institute, Uvwie and Delta State University Abraka, Delta State, Nigeria.

ABSTRACT

Aim: The aim of this study is to assess **the establish** *do you mean to assess and establish?* **does not make sense to say assess to establish** the factors hindering effective maintenance of public buildings in Delta state with a view to establishing common defects in public buildings and significant factors affecting effective maintenance in the study area.

Study Design: It was a survey research; the study was effected via literature review and a well-structured questionnaire. Likewise, physical observations were carried out to substantiate the findings of the questionnaire survey.

Place and Duration of the Study: The study was conducted in Petroleum Training Institute (P.T.I), Uvwie LGA and Delta State University (DELSU), Ethiope West LGA, in Delta state, Nigeria for a period of 2 years.

Methodology: Being a survey research, the study employed the use of review of related literature, structured questionnaire, personal survey, and photographs for data collections. The study respondents were selected using purposive sampling technique. Relative Importance Index (RII), mean scores, frequency tables and descriptive statistics were employed for the data analysis.

Results: The study found out that the four most significant deficiencies identified include; rising dampness problem with RII of 0.8656, cracks on walls with RII of 0.8469, unstable foundation with RII of 0.8094 and defective plastering and rendering with RII of 0.7875 while the three least defects are fungi and small plant attack, insects (termite) attack and timber decay with RIIs of 0.6313, 0.6656 and 0.7031. The most four significant factors affecting building maintenance is Poor supervision with RII of 0.8875 followed by defective construction material, incompetent workforce and non-conformance with specification with RIIs of 0.8719, 0.8531 and 0.8375 respectively.

Conclusion: The study concludes that professionals should focus on teamwork rather than personal competitiveness in ensuring defects free design and construction. Professionals should pay more attention to possibility of defects occurrence when planning construction projects, critical consideration of factors affecting design and construction defects when planning construction activities, engaging required professionals at every stage of construction process, and strict monitory and supervision of construction works among others are recommended.

Keyword: Design, Construction, Defect, Maintenance, Delta State

1. INTRODUCTION

40 Building maintenance plays an important role among other activities in the building
41 operations [1]. Various attempts have been made to give a comprehensive definition of
42 maintenance and to explain vividly what it entails, *Though quoted but need not be verbatim,*
43 *can be edited too to reflect or convey same meaning* [2] defined maintenance as the
44 combination of any action carried out to retain an item in or restore it to an acceptable
45 condition. *Though quoted but need not be verbatim, can be edited too to reflect or convey*
46 *same meaning* Maintenance can also be referred to all necessary work done to preserve a
47 building with its finishes and fittings so that it continues to provide the same or almost the
48 same facilities and amenities and service as it did when it was built [3]. The primary
49 objective of building maintenance is to preserve buildings in their initial functional, structural
50 and aesthetic states. *Can be found on the link*
51 https://archive.org/stream/IJETR_July_2016/IJETR042195_djvu.txt *please cite or reference*
52 *appropriately*

53 Despite the development in technology, buildings still suffer from defects resulting from
54 inadequate design and construction making them vulnerable to unplanned maintenance
55 during their life cycle [4]. Greater part of these defects may be attributed to professionals
56 ignoring maintainability during design and construction, leading to buildings requiring
57 constant repair and maintenance which often translate to high cost causing dissatisfaction of
58 users. *Can be found on the link* [http://docplayer.net/61412118-Design-and-construction-defects-](http://docplayer.net/61412118-Design-and-construction-defects-influencing-residential-building-maintenance-in-nigeria.html)
59 [influencing-residential-building-maintenance-in-nigeria.html](http://docplayer.net/61412118-Design-and-construction-defects-influencing-residential-building-maintenance-in-nigeria.html) *please cite or reference*
60 *appropriately.*

61 Ramly [5] reports that design plays a major role in determining the conditions of a building
62 after completion, mainly in terms of managing defects and maintenance. Also, [6] explained
63 the vital role of design in the early stage of project management. Further [6] stated that a
64 functional design can promote skill, economy, conveniences, and comforts while a non-
65 functional design can impede activities of all types of detract from quality of care, and raise
66 cost to intolerable levels. *Though cited but needs further editing to make it unique instead of*
67 *quoting verbatim.* This is further reiterated by [7] who observed that most professionals
68 ignore the aspect of maintenance during design, and when such design is accompanied by
69 poor construction, we obtain poor buildings requiring constant maintenance during their life
70 cycle.

71 The effect of faulty building design and construction has become one of the major issues in
72 maintaining public buildings in Delta state. Because, most of the professionals involve in the
73 design and construct the facilities most times don't bother whether the facilities they design
74 and construct will function optimally, they just want to complete the job and move to next job
75 while the consequences is left for the client to address [8]. If a building was not properly
76 designed and constructed the client/building owner most time spend large amount of money
77 in the course of maintaining the property. Consideration of maintenance issues during design,
78 construction and post-occupancy stage ensures that maintenance requirements are minimised
79 in the future. This means that the building component can be easily maintained at less
80 expense, in less time and less efforts. Unfortunately, many times building designers often

81 neglect considering a very important aspect which is the possibility to perform future
 82 maintenance needs. It is therefore imperative that the building design and its subsequent
 83 construction method be guided right from the inception. By getting it right the first-time
 84 during design and construction, this will prevent errors that might occurred and subsequently
 85 ease maintenance work and of course reduce the maintenance cost of the building in the long
 86 run. With regards to the above this research is being conducted to establish the factors
 87 hindering effective maintenance of public buildings in Delta state with a view to establishing
 88 common defects in public buildings and significant factors affecting effective maintenance in
 89 the study area.

90

91 **2. LITERATURE REVIEW**

92 **2.1. Building Defects:** Building problems can be classified as defects or failure. The term
 93 ‘defect’ has been defined differently by researchers. It means the shortcomings in the design
 94 and construction practices for some of them, while to others; it implies the inadequacies that
 95 arise from normal wear and tear. Some of these definitions are thus: [9], opined that; a defect
 96 can be defined as a shortcoming in the performance of a building element. A defect will
 97 occur after the building has been occupied. Watt [10] view building defects as “failing or
 98 shortcoming in the function, performance, statutory or user requirement of a building, and
 99 might manifest itself within structure, fabric, services or other facilities of the affected
 100 building”. *Though quoted but need not be verbatim, can be edited too to reflect or convey*
 101 *same meaning* “A defect is a shortfall in performance occurring at any time in the life of the
 102 product, element or building in which it occurs [11]. Further [12] indicates that design and
 103 construction defects are those that are caused due to wrong of methods construction, poor
 104 materials and bad labour practices.

105 According to the Insurance and Risk Management Institute, a building defect is a deficiency
 106 in the design or construction of a building or structure resulting from a failure to design or
 107 construct in a reasonably workmanlike manner, and/or in accordance with a buyer's
 108 reasonable expectation. *Can be found on the link <https://www.irmi.com/term/insurance-definitions/construction-defect> please cite or reference appropriately.*

110 Table 1 shows that there has been recent increase in research on defects in the house building
 111 sector and presented building defect definitions from various authors as compiled by [13]:

112 TABLE 1: Definition of Defects in various context

Context of definition	Definition	Literature Sources
Wider Construction environment	Wider construction at any time in the life of the environment	BRE (1990)
Wider Construction	Non-fulfillment of intended usage environment requirements	Josephson and Hammarlund (1999)
House building	Failing or shortcoming in function, performance,	Ilozor, (2004)

Environment	statutory or user requirements of a building that manifests itself within the structure, fabric services and other facilities of the building.	
House building Environment	A component has a shortcoming and no longer fulfils its intended function	Georgiou (2010)
House building Environment	A final product that does not meet the required quality	Kim,(2007)
House building Environment	Breach of any mandatory requirement by builder or anyone employed by or acting for the Builder.	NHBC (2011)
House building Environment	Something that is unfinished, or an imperfection that is inadequate or causes failure.	Beattie (2011)

113 Source; [13]

114

115 Generally, building defect is defined as a defect or deficiency in the design, the construction,
 116 and/or in the materials or systems used on a project that may not be readily **observable and**
 117 **results in a building, structure or component that is not suitable for the purpose intended.** *Can*
 118 *be found on the link* [https://sites.google.com/site/metropolitanenvironmental/causes-of-failures-](https://sites.google.com/site/metropolitanenvironmental/causes-of-failures-of-building-envelopes?tmpl=%2Fsystem%2Fapp%2Ftemplates%2Fprint%2F&showPrintDialog=1)
 119 [of-building-envelopes?tmpl=%2Fsystem%2Fapp%2Ftemplates%2Fprint%2F&showPrintDialog=1](https://sites.google.com/site/metropolitanenvironmental/causes-of-failures-of-building-envelopes?tmpl=%2Fsystem%2Fapp%2Ftemplates%2Fprint%2F&showPrintDialog=1)
 120 *please cite or reference appropriately.* It includes both design and construction defects that
 121 result in financial harm (either property damage or personal injury) to the owner or to a third
 122 party [14].

123

124 **2.2. Common Defects in Building:** In general, there are several building defects which
 125 usually occur to building parts such as roofs, walls, floors, ceiling, toilets, doors and windows
 126 [15]. Building defects that are commonly found includes; wall crack, peeling paint,
 127 dampness, timber decay, fungi and small plant attack, sagging or deformation, erosion of
 128 mortar joint, defective plaster rendering, insect or termite attack, roof defect, and also
 129 unstable foundation, and services [16].

130

131 **2.3. Factors Responsible for Design and Construction Defects Affecting Building**
 132 **Maintenance:** The performance of buildings depends to a great extent on the quality of its
 133 design and construction decisions. Okuntade [8] stated that inadequacies in the performance
 134 of buildings emanate from deficiencies in design and construction which reflect on the level
 135 of maintenance during operation. Adejimi [7] noted that the extent to which the various
 136 factors contribute to maintenance problems in governmental office buildings in Nigeria are;
 137 inadequate architectural design 6%, inadequate structural design 7%, inadequate electrical
 138 design 9%, inadequate mechanical design 11%, poor construction 12%, use of poor quality
 139 components and materials 14%, natural deterioration due to age and environment 18%,
 140 misuse by occupants 18% and other factors 5%. *Can be edited to exclude all the percentages*
 141 *or better still summaries the findings of that work.* Assaf [17] categorized design and
 142 construction faults contributing to maintenance into (11) groups viz; defects in civil design,
 143 defects in architectural design, defects due to consulting firm's administration, defects due to
 144 construction drawings, defects due to construction inspection and supervision, defects due to
 145 civil construction, defects due to contractual administration, defects due to construction

146 materials, defects due to construction equipment, defects due to specifications and design
147 defects in maintenance practicability and adequacy.

148 Generally, the performance and physical characteristics of building as well as its durability of
149 withstanding environmental conditions and social interfaces are influenced by various factors
150 which are responsible for design and construction deficiency.

151

152 **2.3.1. Factors Responsible for Design Defects:** According to [18] the design related
153 problems are “Problems that are occurring during post-occupancy stage but originated during
154 the design process. There are various types of design-related problems that can be found
155 during post-occupancy stage. They include: Poor material selection, Access, Lack of detail,
156 Poor communication, Poor Ventilation design, Poor structural design, Poor Geotechnical
157 design, Ignoring environmental issue, Lack of standardization etc.

158

159 **2.3.2: Factors Responsible for Construction Defects:** Construction defect are another
160 source of the high cost of maintenance which happens during the construction stage and
161 because of construction performance or material used. Faulty construction is one of the most
162 common causes of early deterioration. A construction defect may include any problem that
163 reduces the value of a home, condominium, or building, it can be the result of design error by
164 the architect, the contractor’s flaw, defective materials, improper use or installation of
165 materials, lack of adherence to the blueprint by the contractor [8]. Okuntade [8], streamlined
166 the identified defects to; inaccurate measurement, Movement or changes in the position of
167 formwork, the use of damaged formwork, Painting on unsuitable surface, Insufficient
168 reinforcement bars concrete cover, Improper construction of joints, Early or premature
169 formwork removal, Poor soil compaction, Inadequate provision for water proofing and
170 drainage, Inadequate curing procedures, Not complying with specification, Using block work
171 as formwork, Uneven mixture of aggregates, Using unwashed aggregate for construction,
172 Insufficient mortar for block work, Improper soil analysis, Defective material

173

174 **3. METHODOLOGY**

175 The research used survey design (a questionnaire survey) to access the design and
176 construction deficiencies on maintenance of public buildings in the study area. Questionnaire
177 were administered to the professionals in the construction industry that shared common
178 characteristics and have knowledge of building design, building construction and
179 maintenance management.

180 The research population include; Architects, Builders, and structural engineers of the
181 facilities/maintenance department of Petroleum Training Institute (P.T.I), Uvwie LGA and
182 Delta State University (DELSU), Ethiope West LGA, in Delta state, and Professionals who
183 engage in design and construction of buildings in the two institutions. The population of these
184 professionals were obtained from the records available at the town planning office and the
185 procurement and maintenance department of the two selected institution. The preliminary
186 survey of the study as shown in table 2 revealed a total of about 120 population which
187 includes vast number of Builders, Architects and Civil Engineers.

188 **TABLE 2: Population of the study**

	PTI	DELSU	TOTAL
ARCHITECTS	16	23	39
BUILDERS	19	30	49
CIVIL ENGINEERS	14	18	32
TOTAL	49	71	120

Source: Field Survey, 2018

189

190 To determine the sample size of the distribution, Taro Yamane's formula was employed,
191 which is given as:

192
$$n = \frac{N}{1 + N(e)^2} \text{-----(1) use}$$

193 *equation editor.*

194 Where;

195 n is the sample size,

196 N is the population size = 120

197 E is the confidence level, the research would assume a 95% confidence level, thus, e =0.05

198
$$n = \frac{120}{1 + 120(0.05)^2} \text{-----(2) use}$$

199 *equation editor.*

200 **n = 92.**

201 The sample size of 92 was adopted for the study.

202 A total of 92 questionnaires were administered, 80 were correctly filled, returned and
203 analysed. This represents 87% of the number distributed. The rest of the 12 questionnaires
204 which represent 13% were either not properly completed, returned uncompleted or not
205 returned. *Check the font size and ensure its same with others.* The returned questionnaires
206 formed the basis for the analysis.

207 The perception of the professionals about design and construction deficiencies on
208 maintenance of public building in Delta State were collected. The
209 respondents were asked to respond to each question based on four point Likert scale where 4-
210 Very Significant, 3-Significant, 2-Somewhat significant and 1-Less significant. The Three
211 consecutive sentences begin with 'the' consider rewording the sentence or use a thesaurus to
212 find synonym data collected was presented in form of tables and descriptive statistics was
213 employed to run the analysis of the demographic profile of the respondent. Relative
214 Importance Index (RII) was used to rank the identified variables with the aid of Excel
215 package.

216 The RII is obtained for each variable using the formula below;

217
$$RII = \sum \frac{W}{A*N} \text{-----(3)}$$

218 Where W= Weight giving to each constant by the respondents relating to (1 to 4)

219 A= Highest response integral i.e 4

220 N= Total number of respondents.

221

222

4. RESULTS AND DISCUSSION

TABLE 3: Building Defects affecting Building Maintenance

s/no	Design's Factors	Total Respondents=80							
		1	2	3	4	N	W	RII	Rank
1	Cracks on walls	5	7	20	48	80	271	0.8469	2nd
2	Peeling of paint	7	12	24	37	80	251	0.7844	5th
3	Rising dampness problem	3	8	18	51	80	277	0.8656	1st
4	Defective plastering and rendering	9	9	23	39	80	252	0.7875	4th
5	Roof defects	14	15	21	30	80	227	0.7094	6th
6	Unstable foundation	5	12	22	41	80	259	0.8094	3rd
7	Timber decay	16	12	23	29	80	225	0.7031	7th
8	Insects (termite) attack	18	19	15	28	80	213	0.6656	8th
9	Fungi and small plant attack	22	15	22	21	80	202	0.6313	9th

Source; Field Survey, 2018

223 **The** results of the data analysis listed in Table 2 shows ranking of the defects affecting
 224 building maintenance. **The** results indicates *remove s.* that the four topmost defects affecting
 225 maintenance in the study area are; rising dampness problem, cracks on walls, unstable
 226 foundation and defective plastering and rendering with RIIs of 0.8656, 0.8469, 0.8094 and
 227 0.7875 respectively. **The** result also shows fungi and small plant attack, insects (termite)
 228 attack and timber decay with RIIs of 0.6313, 0.6656 and 0.7031 respectively as the least
 229 significant defects affecting building maintenance in the study. *Three consecutive sentences*
 230 *as highlighted with yellow begin with 'the' consider rewording the sentence or use a*
 231 *thesaurus to find synonym*

232

233 Based on the findings in Table, the researchers carried a physical survey of the public
 234 buildings in the study area. The result of the survey is presented in the attached plate.

235

236



237

238 Plate 1: Cracks as a result of settlement of foundation



239
240 Plate 2: Dampness of walls
241



242
243 Plate 3: Defective Plastering and Rendering

244 The findings plate 1,2,3 further show that out of the nine design and construction defects
245 identified, the significant defects affecting building maintenance in the study area rising
246 dampness problem, cracks on walls, unstable foundation, defective plastering and rendering
247 which supports the findings in table 4.

248

TABLE 4: Factors affecting Building Maintenance									
s/n	Factors								
		1	2	3	4	N	W	RII	Rank
1	Incomplete detail drawing	6	7	24	43	80	264	0.8250	6th
2	Ignoring changing environmental weather condition	8	15	25	32	80	241	0.7531	15th
3	Ignoring buildability and maintainability in design	6	8	20	46	80	266	0.8313	5th
4	Deviation from standard specifications	8	12	18	42	80	254	0.7938	10th
5	Lack of design standards	14	15	24	27	80	224	0.7000	20th
6	Suitability of design for the existing technology	10	18	25	27	80	229	0.7156	18th
7	Poor structural design	8	8	21	43	80	259	0.8094	8th
8	Ignoring the impact of load on the building stability	13	8	26	33	80	239	0.7469	17th

9	Wrong detailing in production information	8	8	24	40	80	256	0.8000	9th
10	Overlooking the changes in soil condition	10	11	25	34	80	243	0.7594	14th
11	Not considering the effects of climate on materials	14	21	21	24	80	215	0.6719	22nd
12	Poor supervision	2	4	22	52	80	284	0.8875	1st
13	Communication gap between contractors and design professionals	6	17	22	35	80	246	0.7688	12th
14	Defective construction materials	2	7	21	50	80	279	0.8719	2nd
15	Poor quality control on site	7	7	25	41	80	260	0.8125	7th
16	Using improper construction method	3	18	26	33	80	249	0.7781	11th
17	Poor soil conditions	11	19	26	24	80	223	0.6969	21st
18	Use of new and untested materials	7	14	30	29	80	241	0.7531	15th
19	Inadequate curing procedures	10	19	24	27	80	228	0.7125	18th
20	Incompetent workforce	2	9	23	46	80	273	0.8531	3rd
21	Non-conformance with specifications	4	7	26	43	80	268	0.8375	4th
22	Poor construction procedures	6	17	25	32	80	243	0.7594	13th
23	Damaged or improper formwork	5	17	17	41	80	254	0.7938	10th
24	Poor soil compaction	6	26	23	25	80	227	0.7094	19th
25	Inaccurate measurement	5	21	25	29	80	238	0.7438	16th
26	Inadequate concrete vibration	8	21	23	28	80	231	0.7219	17th
27	Improperness or lack of required equipment for construction	12	25	23	20	80	211	0.6594	23rd
Source: Field Survey, 2018									

249 Table 3 shows the ranking of factors affecting building maintenance with their respective RII.
250 The most significant factor affecting building maintenance is Poor supervision with RII of
251 0.8875 followed by defective construction material, incompetent workforce and non-
252 conformance with specification with RIIs of 0.8719, 0.8531 and 0.8375 respectively. The
253 findings in Table 3 further revealed a total of twenty-seven (27) factors that are responsible
254 for defects in building and of course affecting building maintenance in the study area. Among
255 the twenty-seven factors the findings identified the following factors base on the ranking are
256 the top most significant factors affecting building maintenance: Poor supervision, defective
257 construction materials, incompetent workforce, non-conformance with specifications,
258 Ignoring buildability and maintainability during design and incomplete detail drawing. The
259 least significant factors include: Improperness or lack of required equipment for construction,
260 not considering the effects of climate on materials, poor soil condition and lack of design
261 standards.

262

263 5. CONCLUSION AND RECOMMENDATIONS

264 From the above findings, the study concludes that to ensure defects free design and
265 construction processes and in producing a standard quality public building the professionals
266 involve should focus on teamwork rather than personal competitiveness. The search for key
267 factors that influence the maintenance of public buildings is fundamental in ensuring
268 maintainability and sustainability. It was observed that numerous building maintenance

269 problems are partly or entirely as a result of readily identifiable faults in design and
270 construction which could have been foreseen and hence prevented.

271 From the study the following recommendations were made;

- 272 I. Professionals should pay more attention to possibility of defects occurrence such as
273 rising dampness, cracks on walls and unstable foundation when planning construction
274 projects for public buildings in Delta state.
- 275 II. Factors affecting design and construction defects should be critical considered when
276 planning construction activities **so as to** *consider using to* reduce the occurrence of
277 defects which may subsequently create excessive maintenance works.
- 278 III. The required professionals should be brought in at each stage of construction process
279 as this will have **a great impacts** *remove a, A denotes single noun.* on the building
280 performance and thus reduce the possible effects of building defects.
- 281 IV. The client should engaged the service of qualified designers and strict monitory and
282 supervision during construction should be ensured when carrying out a building
283 projects.
- 284 V. Materials use for construction works should be according to specifications, duly
285 certified and rightly procured. Contractors should be made to strictly comply with the
286 materials and construction specifications.

287

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