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Factors Affecting Design toward Affordable Sustainable Housing Delivery in South African Construction Industry

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Abstract

The purpose of this study is to establish the factors that affect the design toward affordable sustainable housing delivery because housing is delivered above budget and unaffordable for low-income earners in South Africa. A sequential mixed method involving qualitative and quantitative approach was engaged for this study, and construction professionals were selected as respondents from nine provinces of South Africa to answer four points Likert scale quantitative questionnaires. A total of one hundred and fourteen (114) questionnaires were appropriately completed and retrieved from the respondents. Data collected were analyzed with descriptive statistics which include PCA, correlation, and regression analysis tools on SPSS version 25 to determine factors that affect the design with the regards to affordable housing delivery in South Africa, interview process is used to validate the findings obtained. The findings indicated that improper design leads to failure in achieving client objectives and causes a change in design and demolition. Lack of design of first-rate living conditions for a healthy environment, design sufficiency, and adaptability to meet people's demand for cost efficient housing were the major factors responsible for unaffordable housing in South Africa. The study recommended that government should establish key policies on housing design to control resource waste and limit construction costs within budget. This will encourage the sensitivity of construction operators about resources control at the planning and implementation stages of housing production.

Keywords: Affordable housing, budget cost, South African construction industry, design factors, and sustainability

1.0 INTRODUCTION

Cost-efficient design is significant toward control of construction costs within budgeted cost in achieving affordable housing delivery. Sustainable affordable housing has been a challenge to the low-income earner sector of South Africa. Based on the fact that construction costs are rising above the estimated expenses. This challenge prevents many people from accessing affordable housing in South Africa (Windapo et al., 2017). In addition, unsustainable practices and high construction costs have rendered less financially privileged people helpless, wherein they have no choice but to be constrained to slums with little or no access to basic amenities (Akadiri et al., 2012; Moghayedi et al., 2021). Ogunbiyi et al. (2014) explained factors that affect design toward affordable housing delivery, include improper design leads to failure in achieving client objectives and causes demolition; design of first-rate living conditions for a healthy environment will enhance cost efficiency; frequent changes of housing design by client affect construction cost negatively; insufficient application of sustainable design principles affects budgeted cost; inadequate design affects the cost of housing delivery; frequent changes to housing design cause variation. Ogunbiyi et al. (2014) further explain that design for waste minimization during production reduces construction costs and omission in housing design significantly, inadequate coordination at the planning stage and closeout stages will affect the efficiency of housing production processes. This effect deters the chance of providing affordable sustainable housing. The gap-spotting from previous study and existing knowledge was established to support the study opinion on design factors that affect sustainable affordable housing delivery, and the concept is to improve on design of affordable sustainable housing delivery. The followings are gap-spotting extract on design and sustainability issues, "South Africa is one of the most urbanised, with majority of the population living in the urban areas. Moreover, poor access to housing manifest through informal settlements, slums, and backyard dwellings mainly in cities" (Mhlongo et al., 2022). Eberhardt et al. (2022) clarified that the considerable environmental impacts, resources consumption and waste generation emanating from inadequate design causes a great concern in construction industry, also, the issues of reuse, repair, refurbish, recycle and recover has grown in recent years to facilitate in minimising these unresolved issues stemming from building industry. Poor communication in the construction is a major contribution to project delays that leads to increase in construction cost. The construction industry faces many challenges throughout the project lifecycle since inadequate communication during design stage among the

consultants, clients and contractors can take several forms, such as directing communication to the wrong person or area, and unclear communication leading to confusion or wrong interpretation in drawings (Suleiman, 2022). Also, disagreement between architects, consultants, contractors, and clients will leads to coordination issues, refers as clashing, arise when project design and drawings don't align well with one another. Common example is haphazard arrangement of columns obstructing views of lobbing areas, and causes safety issues (Rafieyan et al., 2022).

By and large, the objective of the study is to identify and establish factors that influence the design of affordable sustainable housing delivery within budgeted cost. The methodology used in collecting data is a mixed method, which involves qualitative and quantitative processes. The two processes stimulated the aim and objective of the study. The concentration of this study focus on exploration of impart of design factors on affordable sustainable housing delivery and in-depth knowledge of sustainability integration into design in relationship to resources usage for sustainable housing production processes, particularly in South Africa. The study focuses on South African construction industry activities, exploring information on the housing production procedures across all nine provinces, with the intention of obtaining findings that are adequate and relevant, emanating from general opinions among the construction professionals working within housing delivery companies. The study is restricted to housing delivery companies registered under Construction Industry Development Board (CIDB) with grade 3, 5 and 9 general building (GB) and department handling housing delivery in the Western Cape and Gauteng provinces for data collection. However, attention will be concentrated on those construction organisations with enormous experience in housing delivery.

To avert the negative impact of factors that affect the design of affordable sustainable housing delivery, the design team is advised to gain the appropriate knowledge needed to balance all associated economic, social, and environmental issues (Iwaro et al., 2014). In effect, this changes the planning patterns applied by the construction operators at the initiating stage when assessing a building project, thereby increasing the possibility of the sustainability of housing delivery (Akadiri et al., 2012). Makinde (2014) added that construction operators have not integrated effective construction techniques or sustainable design principles into production, designing for better performance of housing to reduce maintenance costs with the consequential effect of housing delivered at high construction costs, which is unaffordable to low-income earners. Similarly, South African contractors are struggling to integrate sustainable design into their production process (King et al., 2017; Rosenberger, 2003). Due to that, housing is delivered at high construction costs across the country (King et al., 2017; Rosenberger, 2003).

The significance of the study is to determine the efficient ways of achieving housing production within budget and to deter the economic effect of the high cost of housing delivery on low-income earners (Ogunbiyi et al., 2014; Windapo et al., 2017). Akadiri et al. (2012) clarified that inadequate enlightenment about standards of housing delivery, and inadequately defined scope of work for contractors causes a change in housing design during production, non-compliance of housing design with government regulation causes changes in design at implementation causes cost increase. Akadiri et al. (2012) further explained that prolonged procedure for the management of design changes causes delay, and a lack of proper implementation of government policy on housing design, the origin of delay in the delivery of the project by the contractors. In developing nations, the most challenging factors that impact affordable housing delivery are poor communication between the design team and contractor at the planning stage causes frequent changes in design and results in a waste of materials. In addition, the non-involvement of contractors at initiating stage of design planning causes alteration of building design at the implementation stage (Golubchikov & Badyina, 2012; Morris, 2007).

Construction operators are frustrated with unpractical decisions regarding housing design, starting right from the initiating stage of production processes, because construction stakeholders are not sufficiently enlightened about the right methods and practices in construction resource usage for sustainable housing delivery (Ogunbiyi et al., 2014). It is equally important to protect cost-effective housing that is affordable to clients and users by avoiding errors and omissions a source for changes in design and demolition during production (Abisuga & Oyekanmi, 2014; Burnett, 2007). Although several studies have been conducted on housing delivery, studies that specifically focus on factors that affect design toward affordable sustainable housing are lacking. The study developed framework of factors that influence design toward delivery of affordable housing within budget, this study is significant because previous studies has not established 36 design factors affecting affordable sustainable housing delivery in South Africa. On this basis, this study has contributed to addressing the gap, by establishing ‘strong factors influencing the design of affordable housing delivery’, ‘general impact factors on design of affordable housing delivery’, and ‘independent variable predicting time and cost increase for affordable housing’. The study developed a framework of factors that impact design for affordable housing delivery, of which this framework of factors established will guide the professionals toward cost-efficient design for affordable sustainable housing in South Africa.

2.0 LITERATURE REVIEW

2.1 Design Issues for Affordable Housing

Excellent design is important for affordable sustainable housing delivery within the cost-effective resources, cost, and time specified at the planning stage of production. According to Ding (2008), the goal of sustainability evaluation on environmental resources is far-off at the design stage of a housing project as it is important to consider it at an early stage, before any detailed design, or even before a commitment is made to proceed with development. Unfortunately, little or no concern has been given to the significance of selecting a more environmentally friendly design that focuses on the use of sustainable materials at the initiating stage; the stage where environmental materials are best incorporated into the housing production process (Boswell & Walker, 2004). Iwaro et al. (2014) agreed that adequate design concerns the aesthetics of a building. This suggests that the successful integration of adequate design into a building production process requires careful insight into potential conflicting goals among the stakeholders for affordable sustainable housing delivery at its earliest stages. This will, as believed, enhance the delivery of affordable sustainable housing at a budgeted cost. On another note, Kwon et

al. (2011) suggested that high performance of affordable sustainable housing requires adequate designs, with clear objectives, and a balanced integrated approach that promotes a cost-effective, safe, secure, accessible, functional, productive, historic, and aesthetically housing (Iwaro et al., 2014).

Planning at the design stage involves plans for the component of building materials that will be used during production to achieve delivery of affordable housing (WBDG National Institute of Building Science, 2017). Kim and Rigdon (1998) claimed that the application of sustainable housing practices is the easiest way of incorporating sustainable design principles in a production process. To achieve sustainable housing, a designer should design for better performance in every aspect of affordable sustainable housing production. Sustainable design enhances efficiency in resource usage; is affordable to erect, maintain and operate; and offers comfort to the occupant (Conte & Monno, 2012).

Potty et al. (2011) explained that the current trend of design and build (D&B) has gained popularity within the construction industry due to its attractive financial aspect. However, many of these designs and built housing projects have ended up in the hands of contractors, who are unable to proceed with the delivery of housing within a specified time and cost. According to Aribigbola (2008), the major reasons for housing to be delivered above a specified budget are that housing production processes frequently begin without a worthwhile investigation to ascertain the risks involved, lack of sustainability integrated approach for housing delivery, lack of identifying discrepancies between drawing and specification impact on affordable housing delivery. Likewise, Atkinson (1999) concurs that contractors are engaged in housing production processes without basic judgment, risk awareness, adequate design for cost-efficient housing delivery, and adequate experience in a housing production process. If the risk of time, design for implementation of new technology, design within project scope, and constant promoting high-quality design is not adequately addressed will result in high construction costs (Clarke & Herrmann, 2004). In addition, if human and material safety is not adequately considered at the planning stage of a housing production process, then housing delivery at upsurge construction costs above budget will be encouraged (Clarke & Herrmann, 2004; Conte & Monno, 2012).

Burgoyne (2008) examines the issue of housing delivery in South Africa, and discovered key variables known to influence the rate of housing delivery such as financial constraints, inadequate design, insufficient resource allocation, and a lack of suitable land significantly affects sustainable affordable housing delivery to the poor people. The actualization of affordable housing remains a challenge in South Africa. This challenge is worsened by the increase in demand for housing by low-income earners residing in a shantytown (Burgoyne 2008). The incorporation of sustainability principles, innovative technologies, and practices have been described as beneficial to the effectuation of sustainable affordable housing delivery in developing nations (Moghayedi et al., 2021). Akinyede et al. (2020) discovered that the challenges of sustainable affordable housing delivery in South Africa occurred due to unsustainable practices in the use of human resources, design-related issues, and matching resources availability with cost and time frame problems. Furthermore, Akinyede et al. (2020) clarified that the involvement of all team members in the planning and implementation process will enhance the mutual relationship, less conflict, and fewer controversies in design while documenting delivery roles and responsibilities among construction team members will increase the satisfaction of interest and efficient resources utilization for affordable housing delivery. According to Taiwo and Misnan (2020), the successful government in developing nations has taken crucial efforts to provide affordable housing to low and medium-income groups, but the efforts have not yielded the desired results. These have led people, families, groups, and organizations to supply housing either on their own or on a rental basis. Although the majority of the poor people live in slum settlement areas in African nations.

2.2 Management Issues for Affordable Housing Delivery

Sustainable housing means sufficient, safe and low cost housing for the poorest people residing in the slum. A sustainable affordable home should be energy efficient, cheaper to run, durable, less maintenance overtime and made from materials that aren't going to harm the residents or the environment (Al Musawi & Al Baghadi, 2023). Sustainable affordable housing delivery is challenged by inadequate management of design problems. Management process involved organizing and supervising small and large infrastructure projects. Which includes planning, controlling, implementation, budgeting, and scheduling management (Bakar et al., 2010). Construction management is carried out to minimize resources waste and impact on the economy and environment (Carter & Fortune, 2007). Similarly, Cole (2005) explained that practices of sustainability management during building production processes require working under major headings: namely, incorporating sustainable design principles, adhering to construction rules and regulations of sustainable design, adequate design for new techniques to achieve cost effective production. Cole (2005) further elucidated that sustainability will help in constant promoting high standard design, design sufficiency and adaptable to meet people demand, design for implementation of new technology to address the issues of sustainability, satisfactory design to meet client and users' objectives toward affordable housing delivery.

At every stage of construction, stakeholders are expected to be duty-bound to the careful use of resources, along with the reduction of the negative impact of waste and pollution emitted by housing (Burnett, 2007). Therefore, sustainable construction refers to both the structure and the process to achieve cost effective production (Akinmoladun & Oluwoye, 2007). The efficient management of affordable housing production processes will aid in achieving a structure that is more environmentally reliable during the entire life cycle of the housing (Akinmoladun & Oluwoye, 2007). Ukoje and Kanu (2014) clarified that a housing production process occurs in stages, which are referred to as life cycle stages; stage 1 = site selection; stage 2 = initiating; stage 3 = planning; stage 4 = design; stage 5 = procurement of competent contractor; stage 6 = construction; stage 7 = operation and maintenance; and final stage, stage 8 = renovation and demolition. Objectives of sustainable housing are achieved by adopting an efficient management procedure and optimizing each phase of the project delivery process for sustainable housing delivery at a specified budget (Akinmoladun & Oluwoye, 2007).

Mbandlwa (2021) clarified that housing carries the weight of a huge number of socio-economic factors, and often a controversial and aggressively debated subject. The citizenry of South Africa has a guaranteed right to adequate housing, of which the state is expected to supply support and services for affordable housing delivery to the people. Still, affordable housing delivery to the low-income earners remains a huge challenge in South Africa. Many studies have reported that the population of the people who are displaced with respect to

housing in developing nations is on the rise (Mbandlwa, 2021; Sunday et al., 2021). The low-income earners have been reported as the worst hit of this worldwide menace, because the low-income earners have no access to affordable housing delivery, many of low-income earners currently living in shantytowns (Sunday et al., 2021).

Marutlulle (2021) stated that there is housing inadequacy in South Africa, and discovered a remedy factors toward housing inadequacy, the remedy is that government needs to engage the private sector, create state-owned enterprises, provinces, and municipalities to unlock strategic parcel of land suitable for human settlements development. In developing nations rapid urbanization and prevalent lack of affordable decent shelter have compelled many people to live in overcrowded informal settlements. This settlement often lacking access to basic services such as electricity, running water and sanitation (Jones & Stead, 2020). Principally, efficient management of cost of construction is essentially connected with affordable housing delivery.

Affordable housing refers to the housing that a household can pay for within the source of income, while still having money left to take care of other domestic need, that means the price of housing must be within the reach of the poor. South Africa has a relatively well developed infrastructure as a basis upon which future housing policy can develop, that means, South Africa has a diversifying and growing economy, which referred to as well developed settlement hierarchy that can form the skeleton for future development and growth, with all these indices of housing growth, affordable housing remains deficit in South Africa (Department of Housing, 1994). The investigation of South African housing challenges revealed that construction industries in South Africa are responsible for the task of understanding and translating strategic sustainability objectives into affordable housing production processes, this has been established as an extremely challenging duty. Effective housing delivery has been worsened by the multinational perspective of sustainability known as economy, society and environment, including a lack of structured methodology and ineffective communication among the stakeholders at various levels of management (Ugwu & Haupt, 2007). But then again, the dares of integration of sustainability into housing production process objectives are particularly acute in South Africa, a country needing extensive affordable housing delivery to stimulate economic growth, poverty alleviation, institutional strengthening, capacity utilisation building, and socio-cultural dimensions that will sustain peace, harmony and co-existence (Ugwu & Haupt, 2007). One of the major duties of any government is to ensure that there are enough houses for the citizens. In view of the shortage, government and many private organisations have been involved in the provision and production of houses for the populace (Aigbavboa et al., 2019). The government promises to provide free housing to the citizens has bred a strong dependency on the state. Thereafter, there was heightened expectation causes massive mobility of people from rural areas and farms into towns where they awaited the delivery of free houses (Bonner et al., 2012; Jeffery, 2010).

After reviewed the literature relating to this study, 36 design factors were discovered impacting affordable sustainable housing delivery in South Africa. The factors are coded, and full name of design factors are as follows; EFD19-Improper design leads to failure in achieving client objectives, EFD6-Establish standard design for production, EFD25-Design of first-rate living conditions for a healthy environment, EFD26-Frequent changes of housing design by client affect construction cost, EFD1-Incorporating sustainable design principles, EFD24-Inadequate design affects cost of delivery, EFD20-Frequent changes to housing design cause variation, EFD22-Adequate design for new techniques will affect cost effective production, EFD23-Changes in design as a source of waste during production, EFD3-Design sufficiency and adaptable to meet people demand, EFD11-Constant promoting high standard design, EFD34-Design for better performance, EFD33-Complexity of design causes changes in design and affects cost, EFD7-Design for waste minimization during production, EFD36-Design for implementation of new technology, EFD21-Errors and omission in housing design affects quality, EFD35-Sustainability integrated approach for housing delivery, EFD2-Discrepancies between drawing and specification impact, EFD13-Coordination of design changes during production, EFD4-Replacement of materials during construction affect cost of delivery, EFD9-Decision taking at planning stage causes changes in housing design, EFD12-Ambiguous design details cause changes in housing design, EFD10-Cost is affected by value engineering at design stage, EFD18-Design housing for environmental performance efficiency, EFD27-Inadequate consideration for housing location at design stage causes change in design, EFD14-Changes in specification by consultant cause changes in housing design, EFD17-Procurement of new materials for housing delivery causes changes in design, EFD16-Inadequately defined scope of work for contractors causes change in housing design during production, EFD8-Design for re-use of materials, EFD32-Non-compliance of housing design with government regulation causes changes in design at implementation, EFD15-Design for the best use of land, infrastructure, and services, EFD30-Prolonged procedure for management of design changes causes delay, EFD5-Government policy on housing design, EFD31-Safety consideration for housing delivery causes changes in design, EFD29-Non-involvement of contractors at initiating stage of design planning causes frequent changes in design, EFD28-Poor communication among design team and contractor at planning stage causes changes in design. Figure 1 below depicts factors that affects design toward affordable sustainable housing delivery in South Africa. The factors are coded and keys to these factors are clearly stated above.

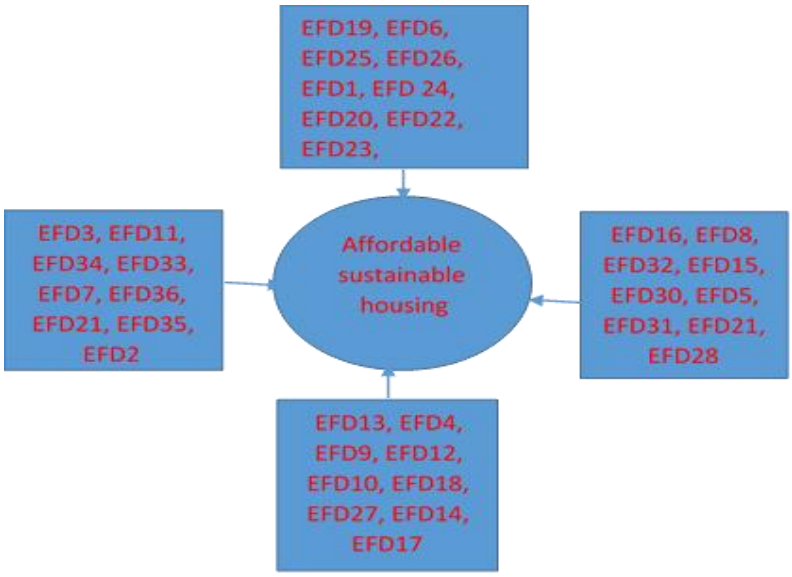

Figure 1 Factors affecting design toward affordable housing delivery in South Africa

3.0 METHODOLOGY

3.1 Data Collection Process

A sequential mixed method research design consisting of quantitative and qualitative techniques was applied to attain the aim and objective in this study. The respondents used for this study are the construction professionals working in South African construction industry. Data were collected from the selected professionals such as architects, contractors, project managers, quantity surveyors, contract managers and site engineers working in the nine provinces of South Africa. The selection procedure used was founded on a non-probability. The selection procedure used was sampling technique because these respondents are professionals that hold strategic positions on their various construction sites in South Africa. Due to their professional positions, the respondents were deemed fit to be experienced and capable enough to offer relevant answers or responses to the questions inquired appropriately and informatively. These respondents were interviewed on the factors that affects design toward affordable sustainable housing delivery in South Africa. The professionals were selected from general building contractors at different grade categories registered with Construction Industry Development Board (CIDB).

A total number of two thousand, nine hundred and thirty-four (2,934) registered professionals were considered for this study. The responses of the respondents were metrically categorized with the use of Likert scale as 1-strongly disagree, 2-disagree, 3-agree, and 4-strongly agree respectively. Questionnaires were administered in batches to the selected sample of constructional professionals by hand and via email. Subsequently, a total number of one hundred and fourteen (114) questionnaires were appropriately completed and retrieved from the respondents. Data collected were assembled on SPSS version 25 accordingly for analysis. Davers and Frankel (2000) describe the data collected process as a technique in which the researcher plans or defies the strategy and methods to be used to gather information for a study, a process which usually includes literature reviewed, questionnaires designed and analysis.

In addition, as data quality seemed crucial to analytical research, thus, all quality techniques were duly observed to ease the attainment of correctness and accuracy during data collection. This study addressed reliability by testing the research questions and the factors in the questionnaire through Cronbach's alpha coefficient. The reliability of the questions measured is 0.9. Similarly, Morse et al. (2002) explain that reliability and validity remain appropriate concepts for accomplishing rigor in a research study.

Data collected were analyzed with descriptive and inferential statistical analysis tools, which include principal component analysis (PCA), correlation and regression analysis on SPSS version 25. The application of these statistical tools enables the determination of the factors affecting the design for affordable sustainable housing delivery in South Africa, along with the variables that predict delivery of housing within the budgeted cost. Results attained were validated by qualitative approach. And relevant validating information were gathered from the four participants selected for a four-case study interview that extends to the four construction organizations as Q-case study 1, G-case study 2, Z-case study 3, and H-case study 4. The selection criteria used indicate that participant must be a construction professional, who works with a construction industry that is registered under the construction industry development board (CIDB) within South Africa. Relatively, information gathered were transcribed to provide the exact interpretation of the people and situation under investigation.

To obtain an accurate sample size for the study, the researcher adopted the second method of checkmarket-easy sample calculator to calculate a representative sample size for the study from *www.checkmaret.com*. Table 1 exhibits overall population of 2934 drawn from the list of registered professionals working in construction industry of South Africa. This figure was inputted into the calculator, and a confidence level of 95% and margin error of 5% were selected from the calculator and entered in Table 2, the sample size falls between 278 and 370, since 2934 can be found between a population of 1000 and 10000, as shown in Table 2. The calculator automatically

generated the required sample size at 340 for the overall population. According to the rule of checkmarket, 20% of an estimated response rate is required for the sample size of a study, further explaining that 30% is distinct as really, really good for an estimated response rate. The response rate for the study is 114, hence to determine the percentage of response rate for this, the calculation was conducted as follows 114/340X100%=33.5%, approximately 34% higher than really good. In addition, based on the number of questionnaires completed by the respondents, one could virtually envisage the quantity of data used for the quantitative analysis.

Table 1 Summary of list of professionals used as population for the study

No.	Name of Profession	Number of Professionals
1	Construction Manager	135
2	Construction Project Manager	421
3	Professional Quantity Surveyor	1897
4	Professional Registered Architect	372
5	Professional Engineer	109
Total		**2934**

Table 2 Checkmarket for sample size of population in unit

Population	Confidence Level = 95% Margin Error			Confidence Level = 99% Margin Error		
	5%	2.5%	1%	5%	2.5%	1%
100	80	94	99	87	96	99
500	217	377	475	285	421	485
1000	278	606	906	399	727	943
10000	370	1.332	4.899	622	2.098	6.239
100000	383	1.513	8.762	659	2.585	14.227
500000	384	1.532	9.423	633	2.640	15.055
1000000	384	1.534	9.512	633	2.647	16.317

4.0 RESULTS

4.1 Respondents' Details

The information on each respondents' company were show in the Table 3 below. Available evidence from the analysis revealed that the majority of participants are working in a construction company, and the least among the respondent participating are from a quantity surveying firm. It is observed that more than 2/3 (approximately 67%) of the respondents are working in construction firm. This implies that adequate information will be collected, since the highest number of the respondents comes from a construction firm and only two from quantity surveying and structural firms. Having more professionals involved in this exercise paved the way for adequate information on the factors that affects design toward affordable sustainable housing delivery. In addition, it will help in reveal adequate information on design planning at initial stage of housing production process. As well as method used for controlling of errors and lapses in building design, which cause delay and unnecessary claims during project production process. The construction firm has highest number of professionals that were able to provide reasons for the influence of design on budgeted cost toward affordable housing delivery. The project manager, architect, quantity surveyor, and structural engineer who have a good knowledge in design planning and implementation were engaged. On this basis the expert answered the questionnaires affirmatively that improper design leads to failure in achieving client's objective. This group of consultants further examine the questionnaires and consented that discrepancies between drawing and specification negatively impact construction cost toward affordable sustainable housing delivery in South Africa.

Table 3 Respondents' information

Variables (Respondent Information)	Frequency	Percentage (%)
Architectural firm	6	5.3
Project consultant firm	16	14.0
Structural firm	2	1.8
Construction firm	88	77.2
Quantity surveying firm	2	1.8
G-Total	**114**	**100**

4.2 Descriptive Statistics Analysis

The result depicted in Table 4 contains 36 factors that affects design toward affordable sustainable housing delivery within budgeted cost. The outcome displayed were obtained through a descriptive statistical approach – the validated factors are arranged sequentially in order of

their impact level on design to achieve affordable sustainable housing delivery in South Africa. The order of impact level of the factors is determined by mean value (MV) of ≥3.0000, factors that the mean value above ≥3.0000 is twenty-eight (28), while factors that (MV) is within ≥3.0000 recorded three (3), other factors that (MV) below ≥3.0000 is five (5). These validated factors have both positive and negative influence on design of affordable sustainable housing delivery in South Africa. The major design factors affecting affordable housing delivery, point toward the facts that client briefing must be adequately integrated into design planning and implemented at every phases of housing production to achieve client objectives. The pathway of achieving client desire hinge on establish standard design for production, and design of first-rate living condition for a healthy environment. Frequent changes of housing design by client and his representative occurred because of the fact that construction professionals lack the knowledge of incorporating sustainable design principles. To accomplish cost efficient housing production, adequate design for new techniques and sufficiency is required. Consequently, it leads to the promoting high standard design for affordable sustainable housing delivery in South Africa.

Table 4 Descriptive statistics analysis of factors that affect design in delivery of affordable housing within budget

Coding	Factors Affecting Design in Delivery of Affordable Housing	Mean	Std. Deviation	Variance	Rank
EFD19	Improper design leads to failure in achieving client objectives	3.2456	0.75915	0.576	1
EFD6	Establish standard design for production	3.2105	0.73441	0.539	2
EFD25	Design of first-rate living conditions for a healthy environment	3.2018	0.69358	0.481	3
EFD26	Frequent changes of housing design by client affect construction cost	3.1930	0.79687	0.635	4
EFD1	Incorporating sustainable design principles	3.1930	0.68971	0.476	5
EFD24	Inadequate design affects cost of delivery	3.1842	0.73552	0.541	6
EFD20	Frequent changes to housing design cause variation	3.1667	0.89162	0.795	7
EFD22	Adequate design for new techniques will affect cost effective production	3.1579	0.69866	0.488	8
EFD23	Changes in design as a source of waste during production	3.1579	0.73568	0.541	9
EFD3	Design sufficiency and adaptable to meet people demand	3.1491	0.69426	0.482	10
EFD11	Constant promoting high standard design	3.1404	0.70243	0.493	11
EFD34	Design for better performance	3.1404	0.78568	0.617	12
EFD33	Complexity of design causes changes in design and affects cost	3.1404	0.76282	0.582	13
EFD7	Design for waste minimization during production	3.1316	0.84679	0.717	14
EFD36	Design for implementation of new technology	3.1228	0.74240	0.551	15
EFD21	Errors and omission in housing design affects quality	3.1228	0.87381	0.764	16
EFD35	Sustainability integrated approach for housing delivery	3.1140	0.78435	0.615	17
EFD2	Discrepancies between drawing and specification impact	3.0965	0.81977	0.672	18
EFD13	Coordination of design changes during production	3.0877	0.74740	0.559	19
EFD4	Replacement of materials during construction affect cost of delivery	3.0789	0.73043	0.534	20
EFD9	Decision taking at planning stage causes changes in housing design	3.0526	0.80751	0.652	21
EFD12	Ambiguous design details cause changes in housing design	3.0439	0.78018	0.609	22
EFD10	Cost is affected by value engineering at design stage	3.0439	0.80254	0.644	23
EFD18	Design housing for environmental performance efficiency	3.0439	0.69627	0.485	24
EFD27	Inadequate consideration for housing location at design stage causes change in design	3.0351	0.77494	0.601	25
EFD14	Changes in specification by consultant cause changes in housing design	3.0351	0.90162	0.813	26
EFD17	Procurement of new materials for housing delivery causes changes in design	3.0263	0.75797	0.575	27
EFD16	Inadequately defined scope of work for contractors causes change in housing design during production	3.0175	0.77554	0.601	28
EFD8	Design for re-use of materials	3.0000	0.83082	0.690	29
EFD32	Non-compliance of housing design with government regulation causes changes in design at implementation	3.0000	0.85186	0.726	30
EFD15	Design for the best use of land, infrastructure, and services	3.0000	0.77574	0.602	31
EFD30	Prolonged procedure for management of design changes causes delay	2.9825	0.67813	0.460	32
EFD5	Government policy on housing design	2.9737	0.76956	0.592	33
EFD31	Safety consideration for housing delivery causes changes in design	2.9649	0.79745	0.636	34
EFD29	Non-involvement of contractors at initiating stage of design planning causes frequent changes in design	2.9649	0.85113	0.724	35
EFD28	Poor communication among design team and contractor at planning stage causes changes in design	2.9561	0.82430	0.679	36

4.3 Principal Component Analysis (PCA)

A summary of the results in Table 5 consists of the principal component analysis (PCA) of the 36 factors that affect design toward delivery of affordable sustainable housing. In this case, PCA was used to determine suitability of the data assembled and the impact level of the factor for affordable sustainable housing delivery. The results obtained indicate that factors with strong and weak power define sustainability level of design for affordable housing delivery. From the same table, Kaiser-Meyer-Olkin measure of sampling adequacy

(KMO) value generated is 0.843, implies that the factor is suitable. Yet, the recommended value is 0.600 by (Pallant, 2013). Notwithstanding, the value obtained is greater. Also, the results obtained from Bartlett's Test of Sphericity is 0.000, that is P=0.000 (P<0.500). This shows that the results are in conformity to the factorability of the correlation matrix. In that case, this means that the factor is significant and adequate for PCA.

Table 5 KMO and Barlett's Test of Sphericity

		Value and Remark
Kaiser-Meyer-Olkin measure of sampling adequacy		0.843 (significant and adequate for PCA)
Bartlett's Test of Sphericity	Approx. Chi-square	2622.530
	df	630
	Sig.	0.000 (significant and adequate for PCA)

From the parallel analysis results, as displayed in the 6 below, it is deduced that three components have eigenvalue greater than the randomly generated data matrix by MonteCarloPA. Then, three components are retained to aid continuation of investigation. The Oblimin rotation is used for the interpretation of the three components retained, and simultaneously used for loading variables. In Table 6, due to the large number of variables, the analysis results exposed components with strong and weak loadings. Observably, pattern matrix has strong component loadings above 0.600 (bold figures), while the structural matrix has three component loadings above 0.300.

Result-wise, figures with strong communalities are indicated in 'lighter green' color. Understandably, a communality must be greater than 0.400 to determine better analysis of factors that affects design for affordable housing delivery. Regarding the highlighted figures among the communalities, the smallest figure recorded 0.425. EFD6 *(establish standard design for production)* has the lowest communality, which is 0.425 as presented in the Table 4. Considering the loading pattern of EFD variables, the variables that converge on component-1 are named as *sustainability design and integration to productivity,* and component-2 is referred to as *design for sustainable adaptability and changes in need of amenities,* whereas component-3 is named *inadequate design for needs and scope causes failure.*

4.4 Validating Quantitative Findings with Qualitative Analysis

The qualitative data analysis was carried out through the use of content analysis methods to substantiate quantitative findings obtained. An interview exercise was executed among four construction manager that are registered with CIDB in South Africa. Afterward, data collected was transcribed in order to interpret and accurately express participant's opinions and situation under investigation. Analysis of qualitative data across four construction organizations, named housing construction firm QGZH. Each of the housing construction firm has respondents, who can respond to interview by identifying and establishing the factors that impact design in affordable housing delivery within South Africa. Thus, the interview results are discussed in accordance with four-case study illustrations (Q-case study 1; G-case study 2; Z-case study 3; and H-case study 4).

Q-case study, the project manager was quoted as saying, "*I will say that improper design occurs at a point where errors and omission cause constant changes in design; however, client interests, needs, and requirements cannot be achieved in such a situation. Accomplishing client objectives in project delivery is significant. Sustainable design principles mean designs for comfort, value, quality, convenience of the occupants, provision of necessary housing amenities to determine the longevity, and housing design for maintenance freedom. All these indices are parameters we use as a design-team to achieve client satisfaction. Therefore, incorporating maintainable design principles into housing production processes hinges on our quality design planning at the design phase. Prior to that, we talk on the requirements of the client at site meeting to infuse quality planning, with implementation at the design stage. We consider cost implications during design meeting, and we implement cost efficient housing production within the budget on our site*."

G-case study, the quantity surveyor discoursed, "*I believed that the aim and objectives of the client will be achieved if improper design are considered at planning stage of design. The client briefing must be integrated into the planning stage of design to achieve cost efficient housing, and to avoid argument and litigations because of constant claims. I realise that cost-efficient techniques practices on site are significant toward social housing delivery. Permit me to reveal to you that sustainable design is a strategic design to establish environmentally friendly innovated housing, and it is considered a specific design to fulfil client and user demands for affordable housing. Gentleman let me confirm to you that housing can only be affordable when the proposed housing is designed to meet people's diverse needs and social cohesion. Sustainable design can be achieved when client and user objectives are well-defined at the design stage to stimulate affordable housing*".

Z-case study, an architect stated, "*Let me say that the suitable design will include client and users aim and objectives established at the briefing stage and improper design limiting the chances of affordable sustainable housing delivery. I understand that sustainable design principles are accomplished when all the necessary comforts required by the client and users are adequately installed into a building. As an architect, I appreciate my involvement in housing design from the client briefing, as this enhances my chance of mirroring the needs and interests of the client accurately on paper and interpreting this idea into reality. Consequently, adequate planning for housing design was considered to incorporate client aim and objectives as a good technique to achieve quality and cost efficiency required. Design planning reduces errors, omissions, and frequent changes in design. Please note that design planning increases the chances of accurate review of drawing to match what was intended at the briefing stage. My advice toward achieving sustainable design is that all construction stakeholders be involved in the design stage of the housing project, so that every opinion is documented and incorporated accordingly. I will say that affordable sustainable housing delivery hinges on sustainable design techniques*".

H-case study, a contractor was quoted as saying improper design leads to failure of achieving client objectives, affecting sustainable housing delivery within budget, "*…our organisation has adequate design principles consistent and helpful to the community. Adequately adhering to client objectives will enhance quality housing delivery. We ensure that all amenities are implemented at the construction stage through to the handing over of houses to the users. The housing we design is maintenance free, supports the lifestyle of the people and ensures longevity, quality, and cost efficiency in use. The inclusion of all of these facilities makes our housing sustainable and interesting. The design of first-rate living conditions for a healthy environment is an option we consider at early stage of design planning to satisfy the client and user's interest*".

Table 6 Principal component analysis results (i.e. pattern matrix and structural matrix of variables)

Coding	Variables	Pattern Matrix Coefficient			Structural Matrix Coefficient			Communalities
		1	2	3	1	2	3	
EFD1	Incorporating sustainable design principles	-	**0.676**	-	-	**0.700**	-	0.493
EFD2	Discrepancies between drawing and specification impact	-	**0.675**	-	-	**0.679**	-	0.508
EFD3	Design sufficiency and adaptable to meet people demand		**0.642**	-	-	0.408	**0.680**	0.531
EFD4	Replacement of materials during construction affect cost of delivery	-	-	0.450	-	0.387	0.480	0.307
EFD5	Government policy on housing design	-	0.489		-	0.496	-	0.281
EFD6	Establish standard design for production	-	**0.606**	-		0.635	-	0.425
EFD7	Design for waste minimization during production	**0.695**	-	-	**0.714**	0.318	-	0.532
EFD8	Design for re-use of materials	**0.681**	-	-	**0.714**	0.340	0.313	0.538
EFD9	Decision taking at planning stage causes changes in housing design	0.568	-	-	**0.678**	0.348	0.460	0.517
EFD10	Cost is affected by value engineering at design stage	**0.679**	-	-	**0.721**	-	0.357	0.532
EFD11	Constant promoting high standard design		0.515	-	0.355	0.558	-	0.364
EFD12	Ambiguous design details cause changes in housing design	-	0.422	-	0.408	0.558	0.485	0.442
EFD13	Coordination of design changes during production	-	-	-	0.341	0.407	0.386	0.262
EFD14	Changes in specification by consultant cause changes in housing design	0.472	-	0.323	**0.621**	-	0.539	0.484
EFD15	Design for the best use of land, infrastructure and services	**0.662**	-	-	**0.676**	-	0.307	0.457
EFD16	Inadequately defined scope of work for contractors causes change in housing design during production	-	-	0.779	-	0.318	**0.759**	0.592
EFD17	Procurement of new materials for housing delivery causes changes in design	-	-	0.417	0.395	0.317	0.539	0.341
EFD18	Design housing for environmental performance efficiency	-	-	0.332	0.318	0.422	0.472	0.311
EFD19	Improper design leads to failure in achieving client objectives	-	-	**0.689**	-	0.390	**0.711**	0.539
EFD20	Frequent changes to housing design cause variation		-	0.416	0.356	0.453	0.557	0.402
EFD21	Errors and omission in housing design affects quality	-	-	0.587	0.335	0.388	**0.666**	0.477
EFD22	Adequate design for new techniques will affect cost effective production	-	0.582	-	-	0.598	-	0.377
EFD23	Changes in design as a source of waste during production	-	**0.682**	-	0.731	-	0.400	0.546
EFD24	Inadequate design affects cost of delivery	-	0.302	0.510	0.509	-	**0.629**	0.471
EFD25	Design of first-rate living conditions for a healthy environment	0.493	-	-	0.605	0.301	0.443	0.421
EFD26	Frequent changes of housing design by client affect construction cost	0.340	-	0.533	0.555	-	**0.666**	0.538
EFD27	Inadequate consideration for housing location at design stage causes change in design	0.355	-	0.408	0.535	-	0.570	0.434
EFD28	Poor communication among design team and contractor at planning stage causes changes in design	-	-	0.741	0.493	-	0.806	0.682
EFD29	Non-involvement of contractors at initiating stage of design planning causes frequent changes in design	-	0.369	0.783	0.393	-	**0.727**	0.658
EFD30	Prolonged procedure for management of design changes causes delay	0.427	-	0.438	0.577	-	0.573	0.482
EFD31	Safety consideration for housing delivery causes changes in design	0.521	-	-	0.588	-	0.407	0.388
EFD32	Non-compliance of housing design with government regulation causes changes in design at implementation	**0.731**	-	-	**0.777**	-	0.459	0.648
EFD33	Complexity of design causes changes in design and affects cost	**0.844**	-	-	**0.796**	-	-	0.650
EFD34	Design for better performance	**0.837**	-	-	**0.815**	-	-	0.675
EFD35	Sustainability integrated approach for housing delivery	**0.855**	-	-	**0.877**	-	-	0.696
EFD36	Design for implementation of new technology	**0.742**	-	-	**0.753**	-	-	0.570

4.5 Summary of Findings from Qualitative Analysis

The results of qualitative analysis conducted with four construction operators working in housing delivery firm were analyzed. Facts deduced from the interview illustrated that improper design leads to failure in achieving client objectives. The respondents clear up that suitable design will include client and users aim and objectives established at the briefing stage, and improper design limiting the chances of affordable housing delivery because client and users aim, and objectives are not properly presented in a design. On this basis the frequent changes of housing design by client occur concurrently on site, which is inimical to affordable sustainable housing production process. Many of the respondents confirmed that establish standard design for housing production is significant to the design of first-rate living conditions for a healthy environment and cost-efficient housing.

5.0 DISCUSSION

5.1 Factors that Affect Design in Delivering Affordable Sustainable Housing within Budgeted Cost

The exploratory study and literature review confirmed unsustainable design practices by construction operators toward affordable sustainable housing delivery. This infers the reason to investigate factors that affect design in the delivery of affordable sustainable housing within budgeted cost. Descriptive statistics that consist of correlation and regression analysis are used to analyzed the data collected. The result revealed major factors that affect design in delivery of affordable sustainable housing within budget. These factors are grouped into different level of influence on affordable sustainable housing delivery, which include "independent variable factors predicting time and cost increase for affordable housing at a significant value of 0.018"; "strong factors influencing design of affordable housing, loading at 0.600, and communalities at >0.400"; and "general impact factors on design of affordable sustainable housing delivery at the MV of ≥3.0000". The major factors identified in the study that connected with the grouping are improper design leads to failure in achieving client objectives; establish standard designs for production reduces cost; design of first-rate living condition for a healthier environment; frequent changes of housing design by client affect construction cost; discrepancies between drawing and specification impact affordable housing design; inadequately defined scope of work for contractors causes change in housing design during production; and changes in design are a source of waste during production. The factor identification range is determined by a mean score of ≥3.0000, at significant value of P<0.500 and threshold loading rate at 0.600 and communalties level at >0.400. This information of grouping of factors helps in identify significant factors for affordable sustainable housing delivery (King et al., 2017; Ogunbiyi et al., 2014; Pallant, 2013; Rosenberger, 2003; Windapo et al., 2017).

The incompetency of construction operators in establishing aim and objectives at the planning stage, and the manifestation of this at design stage through to the implementation stage, causes regular failure in attaining client objectives. In addition, establishment of a standard design for production is simultaneously affected by this irregularity. Therefore, design of first-rate living condition for a healthy environment will reduce maintenance costs, which emerged through environmental impact on housing usage. Delineating the aim and objectives of a client is crucial at the inception of housing production process. Also, these motives required adequate documentation of client briefing to avoid frequent changes to housing design by the client. Essentially, construction operators are advised to incorporate sustainable design principles at the inception of housing production to achieve cost-efficient housing delivery in South Africa (Moghayedi et al., 2021). More so, integration of a new technology is expected to be implemented by soft planning to daunt major changes to design that cause wastes during production, because sudden changes to a new technology during production processes always attract cost increases. Therefore, architects are advised to design cost-efficient housings that require cheap and durable materials to meet both clients' and users' requirements (Abisuga & Oyekanmi, 2014; Akinyede et al., 2020; Boswell & Walker, 2004; Golubchikov & Badyina, 2012).

In a situation where clients' requirements are not linked with the aim and objectives, then improper design would be the product. The effect of this on the production processes will result in frequent claims, which leads to high cost of construction and delay in housing delivery. This explains that influence of a clients on designs could often triggers changes that may lead to restructuring, demolition and/or breakage during construction process. Without prior intellectual reasoning, there is the possibility that delay, and variation will become the norm rather than the exception on site. According to Kim and Rigdon (1998), as adequate design influences the aesthetic of a housing project, successful incorporation of adequate design into housing production requires careful intuition to daunt anomalies between clients and construction operators for a sustainable housing at cost specified.

Similarly, Conte and Monno (2012) explained that effective operation of sustainable housing requires acceptable designs that have clear objectives and a balanced collective approach that is aesthetically pleasing, assessable, cost efficient, safe, and secure. Therefore, planning at the design stage is essential as it involves plans for the constituent of materials to be used during production to attain sustainable housing delivery. However, to attain sustainable housing, it is essential that the architect design for better performance because, among other things, this enhances efficiency of resources (Roy, 2000). This study established a framework in Figure 2 that diagrammatically illustrate the protocol to be observed by construction operators to attain affordable housing delivery in South Africa. The framework will augment construction operator's skill by guiding them on the effective planning of housing design toward cost efficient and productivity at initial, implementation, and close-out stage of a project.

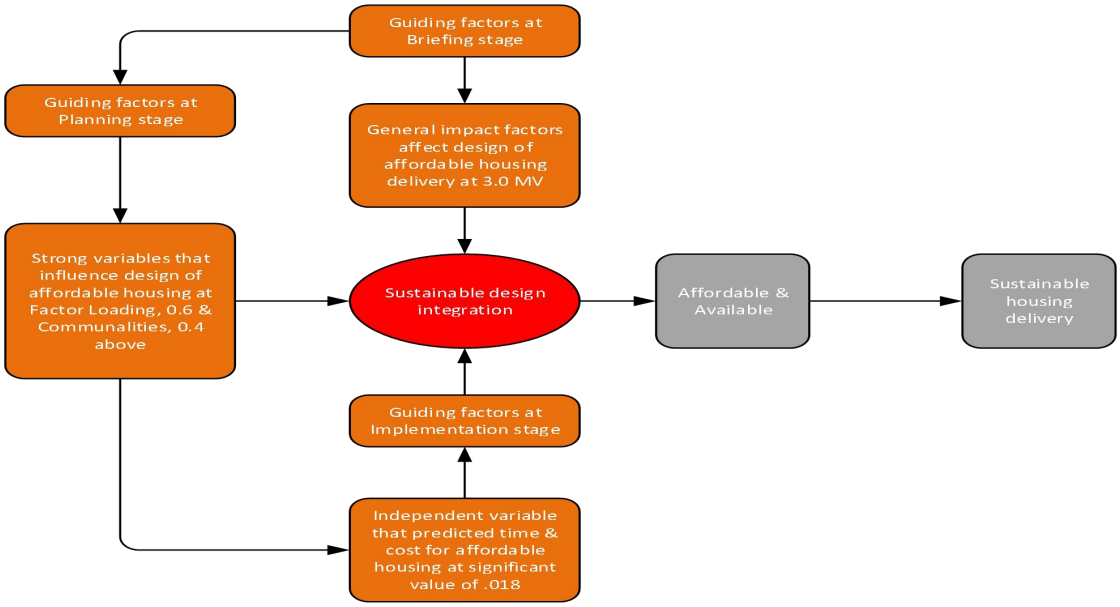

Figure 2 Framework of factors influencing design toward delivery of affordable housing within budget

5.2 Key to Figure 1

5.2.1 Independent Variable Predicting Time and Cost Increase for Affordable Housing at a Significant Value of 0.018

Among the tabularized variables in the Table 6, four variables were identified as time and cost increase predicting variables for affordable housing. These variables are inadequately defined, i.e. scope of work for contractors causes change in housing design during production (EFD16**)**, improper design leads to failure in achieving client objectives (EFD19**)**, poor communication among design team and contractor at planning stage causes changes in design (EFD28), and non-involvement of contractors at initiating stage of design planning causes frequent changes in design (EFD29).

5.2.2 Strong Factors Influencing Design of Affordable Housing, Loading at 0.600, and Communalities at >0.400

Strong factors are determined based on loading rate of 0.600 and communality level of >0.400. This depicts their influence level on the affordable housing. Factors such as, incorporating sustainable design principles (EFD1), discrepancies between drawing and specification impact (EFD2), design sufficiency and adaptable to meet people demand (EFD3**)**, establish standard design for production (EFD6), and design for waste minimization during production (EFD7) exhibited threshold loading rate at 0.600 and communalities level at >0.400 as displayed in the Table 6.

5.2.3 General Impact Factors on Design of Affordable Housing Delivery at the MV ≥3.0000

These factors impact the design of affordable housing with MV ≥3.0000, which include, improper design leads to failure in achieving client objectives **(**EFD19), establish standard design for production (EFD6), design of first-rate living conditions for a healthy environment (EFD25), frequent changes of housing design by client affect construction cost (EFD26), and incorporating sustainable design principles (EFD1).

6.0 CONCLUSION

Affordable sustainable housing delivery in South Africa is a challenge to construction professionals as a result of high construction cost of housing above budgeted cost. Most of the low-income earner's residence in shantytowns because they are unable to pay for the cost of housing delivered by the contractors. On this basis, the study investigated factors that affect design toward affordable sustainable housing delivery. Findings show that improper design leads to failure in achieving client objectives. Established standard designs for production and of first rated living conditions for a healthy environment will control frequent changes of housing design by the client which is a primary source for construction cost increase. Therefore, it is most important for the design team to develop a technique for controlling the frequent changes in housing design during production, a known source for claims and increases in construction cost which hinder affordable sustainable housing delivery to the poor in South Africa.

The present research effort has found out the issues causes unaffordable housing delivery, through establishing an "independent variable factors that predicts time and cost increase for affordable sustainable housing at a significant value of .018"; "strong factors

influencing the design of affordable sustainable housing, loading at 0.600, and communalities at >0.400"; and "general impact factors affecting design of affordable sustainable housing delivery at the MV of ≥3.0000" in controlling the challenges of unsustainable design for affordable housing delivery in South Africa. The study developed a framework of factors that impact design for affordable housing. The operational framework developed in this study could be applied for both the provision of and managing housing production process, and at the same time enhance cost-efficient design toward delivery of housing within budgeted cost and time, as agreed upon by construction managers at initial stage. Sustainable techniques for adequate management of construction cost within budget are developed for construction operators, government officials specializing in housing delivery, housing developers, and policy makers on affordable sustainable housing delivery.

The adequate deliberation of "independent variables factors predicting time & cost increase", "strong factors influencing design", and "general impact factors on design at planning and implementation stage" will regulate errors in housing design which causes delay and increase in cost of housing through variation orders. While at same time improving design team ability. The group of independent variables factors mentioned are inadequate defined scope of work for contractors causes change in housing design during production, improper design leads to failure in achieving client objectives, poor communication among design team and contractors at planning stage causes change in design, and non-involvement of contractors at initiating stage of design planning causes frequent changes in design. While the strong factors influencing design are incorporating sustainable design principles, discrepancies between drawing and specification impact, design sufficiency and design for waste minimization during production. The general impact factor affect design is establishing standard design for production, design of first-rate living condition for a healthy environment, frequent changes of housing design by client affect construction cost and incorporating sustainable design principles. These validated factors will guide construction professionals toward proper documentation of client briefing to achieve aim and objective of affordable sustainable housing delivery.

In general, the study's outcome recommends for practicality in the construction industry, of which may impact the society in a holistic manner. Government should establish key policies on housing design to control resources waste and limit construction cost within budget. This will encourage sensitivity of construction operators about resources control at planning and implementation stages. Aside from that, design of first-rate living conditions for a healthy environment will be attained if the factors established by this study are reviewed by design team at planning stage of housing design. This will have a significant influence on construction cost reduction and maintenance of housing currently occupied. To recommend for further works within the academia, a study is required to evaluate the effect of design on resources utilised for affordable housing delivery. There is a crucial need to evaluate impact of construction resources on housing design at planning and implementation procedures. The construction resources (human, material and machinery) waste emanated from lack of proper design and management processes, effective design planning will help in reduction of resources waste during housing production process. Therefore, there is an urgent need to evaluate the impact of resources management on design.

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