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Risk Factor that Increase Risk of Buildings Collapse in Ethiopia

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As members of the examining board of the final B.Sc. open defense, we verify that we have read and evaluated the final BSc thesis/project prepared by Bekeltu **Feyera, Bona Tariku, and Fraol Worku** entitled **Risk Factor that Increase Risk of Buildings Collapse in Ethiopia**, and recommended for acceptance as a fulfillment of the requirement of **B.Sc. in Civil Engineering**

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Preface

This document is a report as a part of fulfilment for a Bachelor of Science in Civil Engineering. The study is conducted by Bikiltu Feyera, Bona Tariku and Fraol Worku.

Abstract

Building failure or collapse is sometimes reported by local media in developing countries such as Ethiopia. The main objective of this paper was to study the relative frequency of factors that may increase risk of building collapse in Ethiopia. Risk factors were first identified from literature review. An informal interview was then used to identify the factors in local context and formulate a questioner. Finally, the questioner was distributed to Engineers, Construction Managers, and Municipalities that are engaged in building design, construction and supervision.. A total of 48 respondents were considered for analysis. Considering the time and budget limitation a convenience and snowball sampling techniques were used. The questioner was completed using both traditional (paper and pen) and online survey techniques. A descriptive statistic was used to identify the frequency and relative relevance of factors that may increase structural failure of building projects in Ethiopia. Three major factors responsible for building collapse were identified. The first one was poor quality of construction materials. The second factor was poor project management scheme among client, contractor and consultant. The third factor was structural design error. The results of this study may help Engineers, Managers and Municipalities to take actions that may minimize risk of building collapse in context of Ethiopia.

KEYWORDS: Building collapse, Construction material, Project management, Structural Design

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1 Introduction

This chapter introduces the thesis by providing a brief discussion on the issues involved in the research. The scope, objective, problem statement, research question and structure of the thesis are presented in the following sections.

1.1 Background of the study

News of building structural failure is not uncommon in developing countries. Buildings is said to collapse when it can no longer satisfy its primary function of being safe, stable, comfortable and satisfying the occupants. The result is property damage, injuries and loss of life for occupants. Studies state that problems related to use of substandard, defective design: defective construction, foundation failures, absence of proper site and soil investigation, non-adherence to approved building plans, may contribute to building collapse. other factors responsible for building collapse are discussed as follows; lack of maintenance, use of inadequate / improper foundation, poor concrete mix ratio, inadequate structural analysis / design, poor building material specification, natural disaster & climate, inadequate supervision by professionals etc. failure is an unacceptable difference between expected and observed performance.

Structural failure begins to occur when the material is stressed to its upper strength limit causing to rupture or extreme deformations. The ultimate strength of the material or the system is the limit of the load bearing capacity. On reaching this limit, the construction materials could already been damaged, and their load carrying capacity is suddenly decreased permanently. If the system is properly designed, a local collapse should normally not be a cause of instant or gradual failure of the complete building. The ultimate failure strength of the construction elements should be carefully considered in the design of structures to prevent failure.

Faulty construction has been the most important cause of structural failure. The engineer is also at fault here, if the inspection has been lax. This includes the use of salty sand to make concrete, the substitution of inferior steel for that specified, bad riveting or even improper tightening torque of nuts, excessive use of the drift pin to make holes line up, bad welds, and other practices well known to the construction worker. Bad design does not mean only errors of computation, but a failure to take into account the loads the structure will be called upon to carry, reliance on inaccurate data, ignorance of the effects of repeated or impulsive stresses, and improper choice of materials or misunderstanding of their properties. The engineer is responsible for these failures, which are created on the drawing board(Bedru ,M., 2015).

Even where qualified professionals are employed for design and supervision, most clients insist on having the final say on what goes on in the site to the detriment of proper execution of the contract. Unfortunately, if there is any mishap on site, the client put the blames on the consultants and the contractor. It is therefore obvious that client’s penchant to cut corners is one of the problems in the building production process.

Therefore, this research focus on the most frequent factor that affect building structural failure in Ethiopia. Finally building failures occurs due to use of sub-standard building materials, poor workmanship by contractors, use of incompetent contractors, faulty construction methodology, heavy downpour, noncompliance with specifications or standards by developers and contractors, lack of supervision, poor inspection & monitoring, structural defects, defective design/structure, illegal conversion and alterations.

1.2 Statement of the Problem

The construction industry of Ethiopia is growing in recent years. However, the building industry of both the private and public developers in Ethiopia is affected by numerous problems. Building collapse or structural failure of buildings is among the outcomes of these challenges. It is not unusual to read or hear news of building collapse building collapse Ethiopia and other African towns and cities.

In 2016, The Commercial Bank of Ethiopia was planning to evacuate its employee from a G+4 partially completed building in Addis Ababa based on a recommendation from an Engineer that the building may collapse(Capital 2016). On the following days, this building located in Addis Ababa, collapsed (Figure 1a and 1b)(Addis Fortune 2016; Capital 2016). Luckily, the incident happened early in the morning before anyone get in to the office and there were no reported human causality(Addis Fortune 2016). In 2017, a G+2 guest house in Arbanminch, Ethiopia collapsed killing four and injuring four people(XINHUANET 2017). Police arrested the owners of the building (XINHUANET 2017). More recently (October, 2020) a hotel building in Adama, Ethiopia collapsed resulting in four immediate fatalities and two injuries(borkena.com 2020). Similar stories are also available in other Sub-Saharan African cities. A G+5 residential building collapse in Nairobi, Kenya was responsible for immediate death of three people and 8 injuries 20119 (DW 2019). Studies are also available on causes and effects of building collapse in Nigeria(Ede 2013; Hamma-Adama and Kouider 2017).

Building collapse results in primary property damage and mostly a loss of life and/or injury of occupants. Questions are always raised regarding what may have caused building collapse in news-paper articles. Authorities and University Academicians often share their opinion on possible cause of building collapse to journalists(Addis Fortune 2016). However, a scientific study on factors that may increase risk of buildings structural failure in context of Ethiopia could not be found.



a) Building before collapse (Capital 2016) b) Building after collapse (Addis Fortune 2016)

Figure 1.1 Building before and after collapse in Addis Ababa, Ethiopia

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of the study is to identify the most frequent factors that contribute to partial or complete structural failure of building projects in Ethiopia.

1.3.2 Specific Objectives

The specific objective of the study is the following: -

- To identify the most frequent factors that may contribute to building collapses in Ethiopia.
- To identify the relative frequency of different risk factors that may contribute to building collapse in Ethiopia?

1.4 Research question

This research will answer the following main research question

- What are the most frequent factors that contribute to partial of completed structural failure of building projects in Ethiopia?

The study has the following sub-questions

- What factors contribute to risk of building collapse in Ethiopia?
- What is the relative frequency of different risk factors that contribute to building collapse in Ethiopia?

1.5 Significance of the Study

The output of this research will have administrative, policy and academic significances. This helps the city administration to look for innovative approaches to minimize and alleviate the problems. Other urban centres in Ethiopia will also gain experience and will take the findings as an input in their effort to alleviate the problem related with the poor workmanship and improve the status of the construction sector.

Academically, the research output will complement other studies in the area of construction sector; and it will also be utilized as initial information for further detail research works. It is an initiative for other researchers on the related issue and related problems by contributing some findings that can possibly serve as spring board.

1.6 Scope of the study

The main objective of this study is to identify causes of building collapse in Ethiopia. There might be different factors that may cause building collapse. However, the scope of this study is limited to factors such as faulty design, faulty construction, and use of substandard building materials, negligence, omissions, ignorance, foundation and soil. This study does not include factors related to natural disaster such as flood, earthquakes, heavy wind etc. or unexpected events such as conflict, violence etc.

1.7 Limitation of the Study

In the process of conducting this research any research process without limitations or challenges is unthinkable; the main limitation of the study was unwillingness of the respondents to participate in the study this situation is similar to this research too. The process was not smoothly accomplished. The researchers might face with a number of constrains. There are different and many challenges the researcher faced while doing this research, especially at the data collection period. Among them the major limitations are:

- Absence of well-organized secondary data and other source, especially written literatures in Ethiopian context.
- Problem of willingness of some respondents,
- Due to lack of time ,financial and other social problems; and

1.8 Organization of the Paper

This study organized into five chapters. The first chapter focused on the introductory part of the study, which includes background of the study, statement of the problem, objectives, significance, scope and limitation of the study. The second chapter contains literature review part of the study in which theoretical and empirical literatures related with the issue were incorporated. The third chapter deals about the research methodology: research design, approach and method; sampling design, sources of data, data collection methods, analysis and presentation were incorporated. The fourth chapter is all about the data analysis and interpretation, and finally the fifth chapter winds up by conclusion and gives recommendations to the problem related with building collapse.

2 Literature Review

2.1 Introduction

This chapter consists of basic definition and concepts of building collapse, the factor affect building collapse, reviewing studies which were conducted by different researchers on the major types of building collapse. Besides that assessing the major causes building collapse during construction its major causes and the extent of building collapse in the construction industry along different countries have been reviewed. Construction is the process that sets up a portable plant, bring material to the site, and on completion of the work moves the plant away, leaving its output standing Several causes of building failure had been attributed to either natural or man-made phenomena. A natural phenomenon may consist of earthquakes and typhoons while man-made phenomena consist of disasters which may be borne out of man's negligence may in areas such as soil type, incorporating design for extra loads, stress from winds, earthquakes, uneven terrain, use of substandard building materials, foundation works, quality of building materials, strict monitoring of craftsmen and quality of workmanship. Finally building collapse causes in different countries' experiences were assessed. Literature has been written on building collapse in building construction industry.

2.2 Building collapse and its consequence in developing countries

Cases of building failures and consequent collapse of structures in Kenya had reached an alarming stage in the past few years The A five-story building under construction collapsed in the central business district in Nairobi. Also a building adjacent to Imperial Hotel tumbled down when workers were preparing to call it a day The building began to sway, then quickly collapsed, killing at least 11 and injuring dozens. More than 280 construction workers were inside when the unfinished structure in central Nairobi came down. Over 200 people were trapped under the debris of the collapsed structure(Olagunju, R.(2013)).

Reporting collapsed buildings in the country was comparable to flood disaster, earthquake and aero plane clash considering the loss of life and destruction of property in different parts of the country. A number of reasons had been given to explain why these buildings had collapsed and these include reasons like the concrete mix ratio being not right, lack of enough planking and strutting in place to uphold excavations, the column spacing being too wide, poor reinforcement, the slenderness ratio being too high, cost cutting by contractors by changing recommended concrete mix or reducing the amount of reinforcement recommended and a multitude of other reasons.

Finally building failures occurs due to use of sub-standard building materials, poor workmanship by contractors, use of incompetent contractors, faulty construction methodology, heavy downpour, noncompliance with specifications or standards by developers and contractors, lack of supervision, poor inspection & monitoring, structural defects, defective design/structure, illegal conversion and alterations.

In Nigeria and Kenya like any other countries in the world, building collapse is growing at an alarming rate, seemingly uncontrollable or beyond control. The incessant buildings collapse in Nigeria has become a great concern to all the stakeholders and the professionals in the building industry, government, private developers, clients and users, as well as the residents. In Nigeria, building failures have been attributed to the following causes: design faults (50%), faults on construction site (40%) and product failure (10%)). Hall (1984) described faulty design, faulty execution of work and use of faulty materials as major causes of structural failures

2.3 Factors that contribute to Building Collapse in developing countries

The structural engineer is a professional that works based on the architect's layout and provisions to make sure the building stands, and be safe both at ultimate and serviceability limit states with the most economical structural members. The structural stability of a building is fully dependent on in-depth design and construction of the following structural elements: Slabs, Beams, Columns, walls and foundations(Oloyode,S,A(2010).

The causes of building failures is lack of deficiencies at design and construction stages also, poor workmanship, poor monitoring, man's negligence in some vital areas in construction such as soil investigation, incorporating design for extra loads, stress from winds, earthquakes, uneven terrain, use of substandard building materials, is to attributed causes of building collapse in the country can always be traced to unsafe actions of parties involved in building process starting from clients to building consultants, contractors and users(Ukpata, 2006).

Divided causes to building collapse in different major factors that could be related to: poor design; fault at construction; poor material quality and method of construction; foundation failure; fire disaster; natural phenomena, and inadequate maintenance. However, fire disaster and natural phenomena are known causes with certainty when failure happens. There are five major causes that are man-made, where Architecture, Engineering and Construction are quite relevant; the causes are fall under one of the following: Construction supervision, Construction process, Monitoring, Design supervision, Design process(ADEBAYO, 2010).

The quality of the workmen is a measure of their effectiveness and efficiency at all times during construction while the level of building maintenance after its occupation depends on the performance of workmen. The conclusion of (ADEBAYO, 2010)can only be relied upon where the building developer or the contractor are capable and willing to appreciate quality and ready to pay for same.

Defective Architectural and Engineering drawing may result if architects fail to do or insist on the carrying out of feasibility studies, soil and site investigation which are the bases for design of adequate architectural and structural drawings. Others include poor design details, low quality materials and works specifications. Engineers (structure and civil) may contribute if they fail to insist on carrying out essential soil test, foundation design. Errors, omissions and inaccurate data from professionals may lead to problems if not detected on time.

Defective Construction: This arises when contractors fail to carry out the works in accordance with architects and engineers' specifications. They do this in order to maximize profit. Sometimes specified materials are substituted for substandard ones. Others areas of concern include poor concrete mixes, premature removal of formworks and general poor workmanship.

Foundation failures: A building structure can collapse if founded on poor sub-soil, or if the building is not uniformly loaded or if suitable foundation was not specified according to soil nature or due to soil erosion or earth movement under the foundation. Absence of proper site and soil investigation: The avoidance of this to determine suitability of the terrain and soil's bearing capacity, also geotechnical study was fully apply which influences foundation type's spells danger.

Non-Adherence to approved building plans: This comes in form of illegal alteration to approved drawings. This practice if not properly controlled could spell danger years after the buildings are in use. Sometimes, a building originally specified to undergo in-situ concreting is changed to pre-cast methods because the expatriate contractor tends to prefabricate the components overseas.

Deficient Structural Drawing: Any building have the tendencies to collapse when structural drawings are based on false assumptions of soil strength, they can also collapse as a result of faulty structural details

Lack of Proper Supervision: Even where a structural design is not deficient, absence of proper supervision on the site by qualified personnel can lead to building failure. Alteration of Approved Drawings :During construction, many contractors either on the directive of the client or in a bid to cut corners and maximize profit, alter approved building plans without corresponding amendment to structural drawings to the detriment of the structure.

Building without Approved Building Drawing: Building without approved drawings or even no drawings at all, can result to the collapse of the building. More so, when the drawings were not well vetted by qualified professionals or relevant authorities before the buildings are erected. Consequently, without working drawings, all construction is based on assumptions as earlier said, by this; several errors can creep in and can lead to structural failure. Approval of Technically Deficient Drawings: Town Planning authorities at times approve technically deficient drawings. This may be as a result of ignorance on the part of Town Planning personnel who vet and approved these drawings or as a result of outright corruption on their part. Money may at times change hands resulting in the approval of such drawings.

Illegal Alteration to Existing Buildings: Client at times, on their own, alter existing structures (buildings) beyond and above the original design without any working drawings, and relevant Town Planning approval for such development. In some cases, existing bungalows have been converted to either a story building or two or three-story structures without any drawings and supervision by qualified personnel. The result can be anybody's guess.

Absence of Town Planning Inspection or Monitoring of Sites: for some causes town planning Authority staff seldom visit sites to inspect or monitor progress of approved work in sites, the result of which is documented in their forms unfortunately, these details are only known when such buildings collapse and their elements get exposed for all to see. By that time, lives probably may have been lost(Madu, L.C(2005),).

Use of Substandard Materials Substandard: material especially reinforcement rods, steel sections and cement can contribute immensely to failure of buildings. Other substandard materials can also contribute to failure of buildings. Use of low quality materials is one of the major causes of structural failure. Collapse is a state of complete failure, when the structure has literally gives way and most members have caved-in, crumbled or buckled; the building can no longer stand as originally built thereby leading to the inability of the structure to perform its intended functions.

Poor workmanship; Different studies conducted on factors contributing to poor workmanship in building constructions. They found lack of experience and competency of labors, language barrier to communication and lack of communication, unsuitable of construction equipment, poor weather condition, limited time and limited cost as the causes of poor workmanship.

2.4 Poor Project Management

(Ede, A. N (2010),)Say that incompetence management is generally recognized as major factor of poor construction productivity. Poor supervision on site contributes to the poor workmanship on a construction site and it can be seen on many occasions on the job site. He further stated that the management factors may due to the insufficient of supervision on site. In addition, the ability of management of the construction site is the primary cause that affects labours' daily productivity is one of the causes in affecting project quality of project manager. Therefore poor project management is one of the factors contribute to poor workmanship.

2.4.1 Complicated Role of Subcontractor

Kasun, N. H (2006)Stated that the role of subcontractor is one of the factors contribute to construction failure (poor workmanship) and in construction site are not always focus on this factor. However, in fact, the role of subcontractor is important in construction work. This is because most of the site work is completed by subcontractors and the main contractors just depend on the subcontractors. He further stated that approximate 90percent of the site work is executed by variety of subcontractors whereas the main contractor is focused on management and coordination. Poor workmanship also mentioned that labour sub-contracting also arise severe problems in the co-ordination of work and attainment of quality standards. Since there are various types of subcontractor involve in the same construction project, the main contractor is difficult to inspect, supervise and control the works that have been done by the subcontractors. Therefore, complicated role of subcontractor in construction projects can contribute to poor workmanship.

2.4.2 Lack of Experience and Competency of Labours

(Kasim, N. D. B. (2009),)Say that some construction companies in Turkey usually prefer to employ short term unskilled labours and consequently cause the fault in the process of attaining the stability of quality associated issues. Hence, lack of experience and competency of labours must be taken into account as a factor contributes to poor workmanship.

2.4.3 Language Barrier to Communication and Lack of Communication

Different language between the labours and supervisors causes lack of communication skill between failures on the job site. Additionally, from a survey of (Kasun, N. H(2006), n.d.) Showed that exceed 40percent of the respondents from the construction site protested about the insufficiency of communication. Indeed, language barrier indirectly causes the lack of communication between the supervisors and labours. This consequently causes the misunderstanding by the labours in their work scope and then lead to poor workmanship. Another challenge caused by language, as indicated by the contractors, occurs where workers are not able to read instructions and drawings because most of these instructions are in English

2.4.4 Inappropriate Construction Equipment

Chan, P. C. (2006),) stated that Suitability of construction equipment can influence the workmanship quality in construction. Insufficiency of the latest information about the obtainable equipment can influence the project quality. The poor quality of mass housing projects in Turkey mostly because low cost construction techniques which are totally disregarded. Therefore, unsuitable construction equipment can cause low quality of workmanship in construction.

2.4.5 Poor Weather Condition

Dai et al. (2009) stated that the extreme climatic condition is one of the factors that affecting construction labour productivity and workmanship. Faisal et al. (2006), say that the climate of Saudi is hot and severe during summer that causes some of the construction works very hard to carry out, such as concreting. As a result, the quality of workmanship is affected.

2.4.6 Limited Time

Insufficient time caused the construction projects executed to be rushed. Many concurrent works were carried out and inadequate checking had been carried out by the senior managers sequentially caused by the speed of working. As a result, the deficiency of workmanship had been happening. In short, limited time causes a low quality of workmanship in construction(Olajumoke A,(2009),).

2.4.7 Limited Cost

Insufficient cost or budget would cause inadequate allocation of cost in construction project. Labour cost is included in construction cost. Labour element is considered as the most difficult component to price within the reasonable level of accuracy. Obviously, labour cost estimation is considered as uncertainty. Contractors who are not preparing the sufficient budget for the project was cause the labour cost cut down correspondingly. As a result, the labours supplied are not sufficient to complete a project and construction failure may appear (Ikpo, I.Y(1998)).

2.5 Summary on Identification of Gaps of the Literature

The Literature is revised about building collapse and the main causes of the building collapse problem. The main reason of the literature review is to study from the others either developed or developing countries, to adapt the best experiences for our construction and to identify the gap on researches to fill in this research. Most of the literature reviewed indicates that previous researchers only concentrated on general causes of building collapse in construction. Ethiopia is a developing country and promotes construction in many sectors of its economy. There was need to carry out a study to identify the effect of workforce in construction productivity.

From the literature review, building collapse is either design or construction collapse; the reason is include any deficiency in the performing of the design, planning, supervision, inspection, construction, or observation of construction of the building. This design error is the result of professional's failure to produce a complete, accurate and well-coordinated set of design and construction documents more over construction failure result of unskilled labour not able to construct buildings. Moreover, it compiles about method of building construction failure. And the building collapse can detect on pre-construction stage: by In situ exploration and tests and laboratory tests; during construction stage: low concrete quality/strength, loose tie of reinforcement bars causing misplacement of the bars leading to over stressing of the structure should be supervised; and on post-construction stage methods for defect detection include observation, inspection, checking work and test samples are methods of detection of defects. In addition to that, there are various causes of building failure like design error, material quality, poor workmanship, poor project management, lack of skill, foundation failure, subsurface deficiencies, user activities, maintenance, climatic conditions are some of the causes of building collapse.

From the above causes the literature gave emphasis on building collapse due to manmade; because as reviewed literature from developed and developing countries. Poor Material quality and Poor workmanship is the major contributor to poor quality of construction; with various impacts like poor quality, high cost, and delay completion time. Therefore, the literature revised factors contribute to building construction or lack of experience and competency of labours, language barrier to communication and lack of communication, unsuitable of construction equipment; poor weather condition, limited time and limited cost are some of factors for contributing for building failure. During the literature review there are worked researches in our country which is related with building collapse. Therefore the research is tried to fill the gap by giving emphasis on building collapse.

3 Research Methodology

3.1 Introduction

This chapter describes the procedure followed by this paper. The research approach, method, sampling design, sources of data, how to collect data from the target population, analyse and present the analysed data, so that enable the researcher to address the set objectives. First a literature review was used to identify risk factors and study areas. Engineers and Construction management professionals were then informally interviewed to identify the risk factors and modify the questioner in local context. Manual and online questioner survey was used to collect data from to Engineers, Construction Managers, and Municipalities that were engaged in building design, construction and supervision. A statistical analysis (descriptive statistics and correlation analysis) was then be used to answer the research questions. The studies was finally concluded and give recommendations based on results. The purpose of the survey was to determine the professionals‟ view to causes of building failure and collapse in Ethiopia. The primary data for the investigation was developed from key professionals in the Ethiopia construction industry through a questionnaire survey. The survey was limited to stakeholders of the industry (clients, consultants and contractors) in the fields of Architecture, Building, Engineering and Surveying. To evade bias, the respondents were chosen randomly from amongst consultants, contractors and clients. Clients are construction professionals from government agencies and private developers. 54 questionnaires were distributed randomly to architects, builders, engineers and quantity surveyors in several organizations. Forty Four (44) of the distributed questionnaires were returned for analysis and thereby representing 77.78% response rate which is considered adequate for the study. The respondents were tasked to rank the main causes of building failure and collapse as well as to identify the building elements that fail to cause building collapse. The simple descriptive statistics and ranking were used to analyses the collected data. The overall proposed research framework is demonstrated in figure 1.

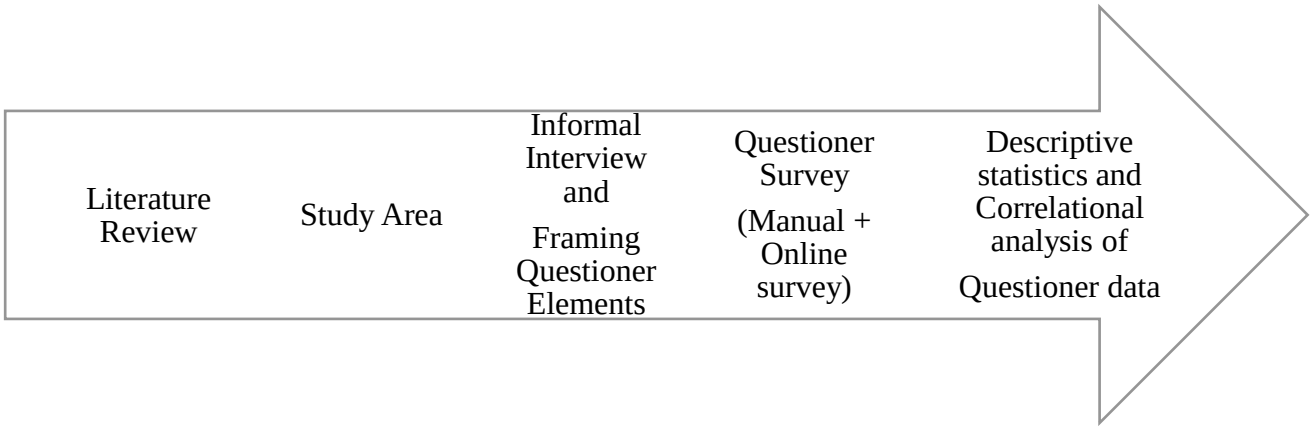


Figure 3.1: Research Frame work used for the study

3.2 Research Design

There are two types of research approaches, namely: quantitative, qualitative. Quantitative study is a study where purely quantitative data and analysis techniques are adopted while qualitative approach makes use of purely qualitative data and analysis.

3.3 Source of Data and Research Instrument

3.3.1 Primary Data

Primary data was collected through questionnaire, from clients, consultants and contractors. Most of the data collected through questionnaire survey are ordinal in nature and used to rank the problems in their order of significance.

The answers to the structured part of the questionnaire are based on Likert-scale of five ordinal measures of agreement towards each statement (from 1 to 5). As discussed earlier Likert's scale of five ordinal measures of agreement towards each statement (1, 2, 3, 4 and 5) is used to calculate the mean score for each factor that is used to determine the relative ranking. The mean score (MS) for each variables is computed by using the following formula;

$$\sum ((f * s)/N) \text{ [16]} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where: MS = Mean Score

F= frequency of responses for each score

S =scores given to each factor (from 1 to 5)

N=total number of responses concerning each factor

3.3.2 Secondary Data

Secondary data which involves information from published text such as journals, government publications, dictionaries, and reliable internet resources were used to compliment the primary data.

3.4 Questionnaire Design

A questionnaire was developed to assess the perceptions of clients, consultants, and contractors due to the importance index of building collapse during the construction phase and after construction. The need for distributing questionnaires, for the residents were to identify the severity as well as to show collapse which are observed after occupancy and through age. Causes and impact of building collapse in construction projects in general were first examined and identified through a relevant literature review and then based on the questionnaire data review the perceptions of clients, consultants, and contractors. Finally, the factors contributing to building collapse were assessed by the client, contractor and consultant.

3.4.1 Study Area

This study was be focused on Residential projects partial of completed structural failure of building projects in Ethiopia (Figure 3.2). The online survey addressed professionals working in building construction industry in different parts of Ethiopia.

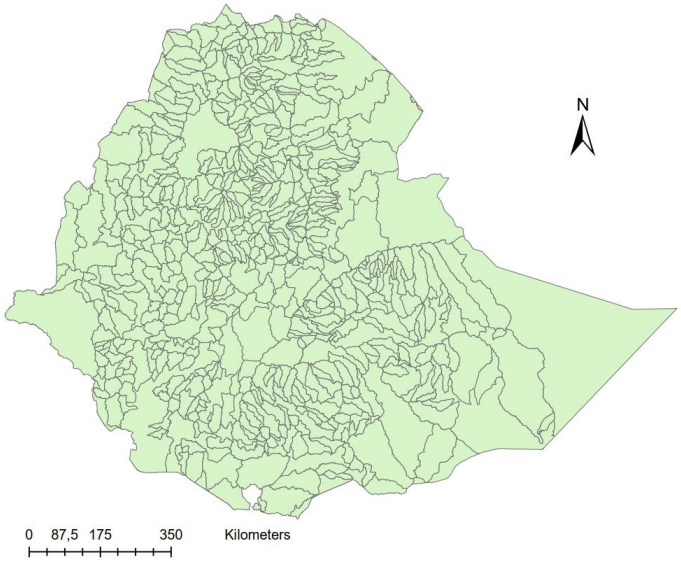


Figure 3.2: Study Area: Ethiopia

3.5 Research Design and Approach

There are two basic types of research approaches, quantitative and qualitative approach. In order to achieve the objective of this study and answer the research questions, the study used qualitative approach. In addition secondary data from journals, reports, internet, and previous works of other authors on the subject matter. Due to time and budget constraints, this paper was not conducted case study approach or field visit to collapsed structures.

3.5.1 Formulating Questioner Elements

A self-administered questioner was be used to identify the most frequent factors that contribute to partial or complete structural failure of building projects in Ethiopia. A questioner attached in Appendix A will be used. The questioner has 19 elements. The questioner elements are prepared based on literature review and results of informal interview. Describe the respondent's demography. (Age, gender, education level of respondent).

Design Error or faulty design also contributes to building collapse related risk factors that may increase risk of building collapse. Structural Engineer is not taking enough time to appropriately design the structure Site Supervisor of consultant failed to detect or ask for explanation from design structural engineer about design drawings that may compromise structural integrity of the building.

Site Engineer of Contractor failed to detect or ask for explanation from design structural engineer about design drawings that may compromise structural integrity of the building. Project manager of Owner failed to detect or ask for explanation from design structural engineer about design drawings that may compromise structural integrity of the building. Design modification related risk factors that may increase risk of building collapse.

Owner request for design modifications after significant works are already started that may risk structural integrity (e.g. request for additional floor). Structural Engineer do not take enough time to evaluate Owner request for design modifications after significant works are already started that may risk structural integrity (e.g. request for additional floor). Supervisor do not have enough courage to challenge and reject if required Owner request of Structural Engineer proposal for design modifications after significant works are already started that may risk structural integrity (e.g. request for additional floor). Site Engineer lack of commitment to carefully evaluate Structural Engineer proposal for design modifications and request for explanation in case of doubts on deign on construction method to implement the design.

Substandard building material related risk factors that may increase risk of building collapse failed to investigate the appropriate quality of materials for construction at site using appropriate tests (e.g. Silt content of sand, tensile strength of steel)**.** Site supervisor failed to conduct regular testing to monitor the quality of structural elements as per the specification (e.g. cube test)Site Engineer Contractor site Engineer lacks experience to detect substandard materials for construction Contractor site Engineer failed to report to supervisor or project manager substandard materials for construction Project Manager/Owner Project manager/owner forced the contractor to use low quality material either as a part of the agreement or other issues (e.g. nepotism).

Faulty or poor construction Method related risk factors that may increase risk of building collapse. Supervisor errors also contribute Consultant's supervisor doesn't have the knowledge/skill/experience with work methodology to guide works. Consultant’s supervisor failed to detect problems on contractors work methodology (e.g. not regularly available at site).Contractor Site Engineer Employing cheap labour Poor workmanship of to save money (e.g. inexperienced workmanship on mixer operator or vibrator). Contractor sites Engineer do not have experience how to implement or manage works to the required standards. Project Manager Project manager/owner forced the contractor to use construction method either as a part of the agreement or other issues (e.g. owner forced contractor to use substandard panel as a formwork.

Consultant supervisor corruption has led to turning blind eye to poor construction of works and compromised quality Approved works without looking due to some reason (e.g. not available at site, corruption)Site Engineer Contractor site Engineer or other personnel used bribery as a means to reduce pressure or control from consultant supervisor or project manager.

Project Manager Corruption has led to turning blind eye to poor construction of works and compromised quality Owner Failed to higher competent contractor, consultant and project manager in an effort to save money. Higher incompetent project manager or other personnel that negatively influences the quality of works. The questioner was be completed using both manual (paper and pencil) and online survey techniques.

3.6 Data Collection

3.6.1 Data Collection Method

An informal interview of Engineers and construction project managers at Wolkite University was primarily be used to localize the risk factors identified from literature review and prepare a questioner. A primary data was then being collected using a questioner survey (Appendix A).

3.6.2 Sample Size

Considering Limitations of resources, this study used convenience sampling technique. The study collected a questioner survey data of 50 professionals engaged in design, construction, supervision and permit of building constructions in Ethiopia.

3.6.3 Data Analysis

This study used descriptive research method .The major purpose of descriptive research is to describe the state of affairs/situation as it exists. It gives a basic description of statistical unit under investigation this descriptive type of research method will be employing by the researcher. The reason why the researcher is selected the descriptive research design is able to identify the major causes of building collapse in Ethiopia.

Qualitative analysis (informal interview and open ended question) using a descriptive and correlation for questioner using SPSS/Excel tool. Four items were prepared for a client, consultant and contractor profile for obtaining information about the respondent's organization such as the name of the organization, company type (client, consultant or contractor) and respondents' job position.

The research attempted to touch most of the relevant problems under the study that enables to appreciate all the concerned issues under the subject area. A descriptive statistical method has been used for the analysis of the data which provides a general overview of the results in order that some kind of interpretations and discussions can be made on the results. Moreover, reviewed literature was also used as one of the main backbone for the analysis of the findings. For summarizing of the collected data and to determine the number of responses belonging to each category, frequency tables and charts have been used.

Finally, the results of the questionnaires and case studies were analysed using quantitative data analysis software known as SPSS/Excel version 20. Frequency tables and descriptive statistics were constructed to display results with respect to each of the questions of general information and cause of building collapse. Ranking analysis was used to rank the common types of building collapse, the degree of importance of the factors contributing to building collapse and the degree of effectiveness of measures to overcome quality problems using mean score value.
Correlation analysis used to identify the significance of relationship between the mean responses of the respondents in this research. The Spearman (rho) rank correlation coefficient for any two groups of ranking is given by the following formula. Based on the five-point Likert rating scale, a standard method of ranking was used which is the relative importance index (RII).

$$\text{Relative Importance Index (RII)} = \frac{\sum W}{A \times N} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 2$$

Where:

W is the weighting given to each element by the respondents. This will be between 1 and 5, where 1 is the least significant impact and 5 is the most significant impact;

A is the highest weight; and

N is the total number of respondents.

4 Results

4.1 Introduction

This Chapter describes the result of analysis of the data collected through questionnaires, case study, site observation and literature review concerning causes, effects of building collapse Ethiopia. The survey results were analysed and the findings are presented below. An initial observation was a substantial difference in the response rates for the surveys, where same method of notification and delivery was used. The difference may potentially credited to the relevance of the investigation to the parties involved: engineers can be seen more interested and highly linked to the subject (building failure and collapse), it could also be associated with the number of disciplines involve in the field of engineering; followed by architects, quantity surveyors then builders. The tables below presented the response percentages as well as roles‟ distribution. The technique adopted for analysis of the questionnaire and interview survey is frequency distribution. The data are presented using appropriate data presentation tools (tables, graphs and photos).

4.2 Survey Result and Analysis

The survey shows that the majority of the respondents (54.34%) have a working experience of more than five years in public construction works such as building, road, water, irrigation, and other infrastructure projects. This could demonstrate that the respondents have sample and adequate knowledge and expertise on public works contract. Thus, it can be concluded that the result from the survey is relatively accurate and reflects the actual situation in the domestic construction industry with respect to the focused contract provisions on the standard condition of contract together with its implications. Besides, considering the relatively high experience of the respondents and the number of responses.

4.2 Questionnaire Response Rate

Table 4.1 Response Rate of the Questionnaire

Nº	Respondents	Questionnaire Distributed		Returned Questionnaire		Unfinished Questionnaire	
		Nº	No	%	No	%	No
1	Client	12	6	50	6	50	9
2	Consultant	20	10	50	10	50	15
3	Contractor	13	5	39	8	61	8
4	Project Manager	15	10	75	5	25	10
5	Site Engineer	20	12	60	8	40	15

Note: Nº=number and %=Percentage

4.3 Respondents Academic and Work Background

Include highest educational achievement, working experience in the construction industry, type of organization respondents have worked, class of the organization, position on this site, years of experience in one big table here describe it in writing. The respondent's Educational level is shown in table 4.2 below. 25.45 percent of respondents have M.Sc. and 60 percent have B.Sc. Generally, 85.45 percent of them have B.Sc. and M.Sc. This indicates great confidence in their answers. It is very good to realize that over 75% holds bachelor's degrees and above; and about 80% of the respondents have over 4-7 years and greater than7years practicing experience and 20% are between 1-3years experience also. Above are charts presenting the educational and experiences of the respondents.

Table 4. 2. Summary of respondents academic and work profile

Total number of respondents		44				
Educational achievement		B.Sc.	M.Sc.	Other	Not stated	
		21	20	3	4	
Working Experience		1-3 years	4-7 years	>7years	Not stated	
		20	10	8	4	
Type of organization		Client	Consultant	Contractor	Other	Not stated
		16	17	12	5	3
Class of the organization		I	II	<=III	Other	Not stated
		13	2	5	5	3
	Site Engineer	Office Engineer	Technical Expert	Project Manager	Other	Not stated
Position on Site	10	2	1	4	3	4

4.4 Frequency and Relevance of Building Failure and Impact

The survey revealed that over 50 disclosed that buildings fail and collapsed „often" while the remaining majority believed it does but „sometimes". Buildings collapse Ethiopia is not just limited to buildings in operation but even buildings under construction. Subsequently, considered the impact of this menace as moderate while the second majority believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to structural failure

4.4.1 Frequently Stated Factors That Contribute To Building Collapse in Ethiopia

Mean Score and Ranking of the most causes of building collapse in chart below

Table 4.3 Mean Score and Ranking of the most Causes of building collapse

Nº	The most Factors for building collapse	Client		Consultant		Contractor		Total	
		MS	Rank	MS	Rank	MS	Rank	MS	Rank
1	Poor workmanship	3.86	2	3.57	4	3.60	4	3.54	2
2	Design error	3.54	3	4.00	1	3.80	3	3.36	4
3	Poor project management	3.81	2	3.90	2	4.30	1	3.73	1
4	Unsuitable construction material	4.00	1	3.63	2	2.76	8	3.18	6
5	Inadequate time	3.12	7	3.54	5	2.10	9	3.45	3
6	Lack of experience	3.82	2	3.6	4	3.45	6	3.54	2
7	Inappropriate construction equipment	3.62	4	3.9	2	3.54	5	3.45	3
8	Complicated role of subcontractor	3.80	3	3.3	6	3.36	7	3.45	3
9	Lack of skill	3.73	2	3.27	7	3.67	4	3.54	2
10	Bankruptcy of contractor or owner corruption	3.10	8	2.99	8	2.11	10	3.36	4

MS=Mean score

Professional skill, limitation Contractor ignorance to follow mix design stated by supervisor, Corrupted professionals seated on the municipality, technological gap, poor workmanship, error Lack of Professional ethics, unable to construct as per the specification, Change of building function (usage after completion), Lack of proactive supervision ,Segregation, Works in general involved in the industry lacks adequacy Requirements from public body (entry barrier to construction industry Low experience of contractor poor construction management soil bearing capacity lack of proper management maintenance activity during the elastic liquid of the project Works in general involved in the industry lacks adequacy natural disaster (e.g. wind)Foundation soil failure.

Relative Importance Index (RII) in table 4 below, It can been seen that the material quality is the most (ranked 1st) cause to building failure followed by workmanship and work methodology(ranked 2nd); all these relates to how and with what the building was made up of. It is obvious that building materials are checked before use at construction stage and primarily by supervisor. Therefore supervision is very necessary and critical to achieving whatever is in the design.

Table 4.4 Rating to causes of building failure and collapse

Number of Rank R & Weighted value W impact	Weight 5	Weight 4	Weight 3	Weight 2	Weight 1	∑ W	RII	Rank
Overall project management issues	88	87	114	90	7	384	0.877	3
Design errors and modification	73	135	84	75	32	340	0.772	4
Material quality	69	94	173	70	10	425	0.9659	1
Workmanship and work methodology	57	102	114	57	19	399	0.906	2
Geotechnical issues	43	90	79	41	4	257	0.584	5

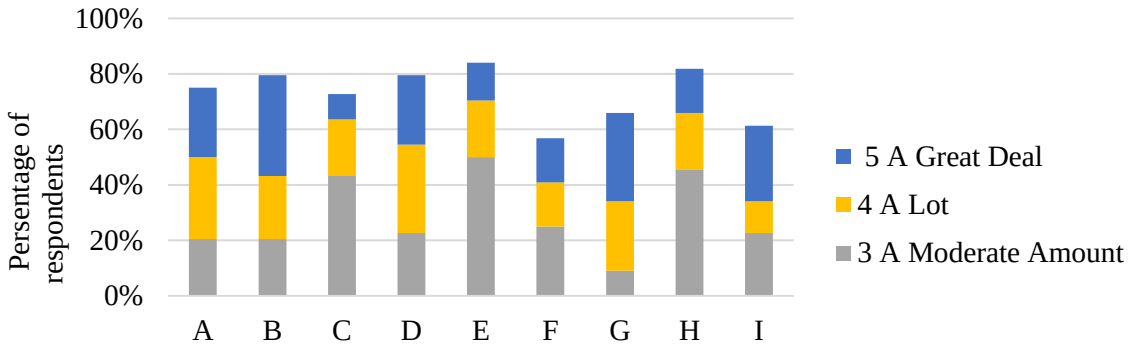
4.4.2 Role of Overall Project Management Issues

Construction project management is the overall control of the total management process to optimize the three attributes of the process: Quality, Schedule and Cost. The study to identify poor project management causes building collapse. Out of the17 contractors interviewed, 15 agreed that poor project management causes building collapse. Project completion within the allocated budget and duration, satisfying the client's functional requirement Construction to specified standards Provision of safe and satisfactory working condition the contractors said that many building were constructed by client themselves to save costs. The clients further indicated that they get artisans for the different tasks and manage themselves.

This shows that there is no proper management system in place to ensure that workmen work efficiently and to the desired quality of finish. Contractors mentioned that quality management, which is the coordination of time, cost and quality enhances the building. Poor project management is lack of clear goals and success criteria also lack of communication, budget issues, inadequate skill of team member, lack of accountability, inadequate risk management. The efficient management of these resources ensures successful project completion. The contractors further stated that the level of workmanship determines the quality of the building; therefore proper management of craftsmen ensures that their efforts are guided to achieve the desired goal.

In many cases the developer himself manages the project even when he has little or no experience in construction.

Relevance of overall project management issues of building collapse due to poor project management (Figure 4).The survey revealed that over 45% disclosed that buildings fail and collapsed „often" while the remaining majority (32%). Buildings collapse in Ethiopia is not just limited to buildings in operation but even buildings under construction 50% considered the impact of this menace as moderate while the second majority (30%) believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to overall project management issues.



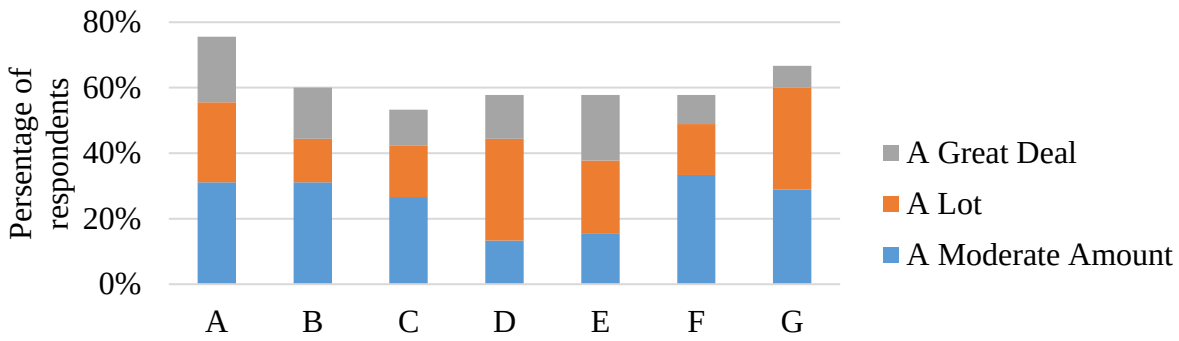
Risk factors that may increase building collapse in Ethiopia

Key	Text
A	Poor project management
B	Unsuitable construction material
C	Inadequate time
D	Lack of experience
E	Inappropriate construction equipment
F	Complicated role of subcontractor
G	Lack of skill
H	Bankruptcy of contractor or owner
I	Corruption and Fraud

Figure 4.1 Relevance of overall project management issues building collapse

4.4.3 Role of Design Errors and Modification

Relevance of design error in construction projects issues of building collapse design modifications after significant works are already started that may risk structural integrity (e.g. request for additional floor). Structural Engineer design error Project manager of Owner failed to detect and challenge structural design error. Site Engineer of Contractor failed to detect and challenge structural design error Site Supervisor of consultant failed to detect and challenge structural design error (Figure 5). The survey revealed that over 40% disclosed that buildings fail and collapsed „often" while the remaining majority (31%) believed it does but „sometimes". Buildings collapse in Ethiopia is not just limited to buildings in operation but even buildings under construction 33% considered the impact of this menace as moderate while the second majority (31%) believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to design errors and modification.



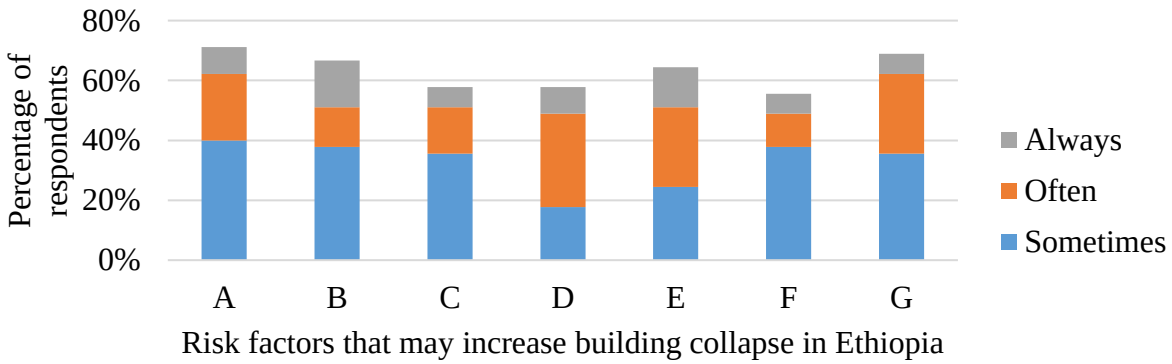
Risk factors that may increase building collapse in Ethiopia

Key	Text
A	Structural Engineer design error
B	Project Manager failed to detect and challenge structural design error
C	Site Engineer of contractor failed to detect and challenge structural design error
D	Site supervisor of consultant failed to detect and challenge structural design error
E	Owner request for design modifications after significant works are already started that may risk structural integrity
F	Structural Engineer approval for design modifications after significant works are already completed

G	Supervisor failed to challenge new proposal for design modifications after significant works are already completed

Figure 4.2.Relevance of design error in construction projects in Ethiopia

Frequency of design error in building collapse issues of building collapse in Ethiopia. The survey revealed that over 40% disclosed that buildings fail and collapsed „often" while the remaining majority (31%) believed it does but „sometimes". Buildings collapse in Ethiopia is not just limited to buildings in operation but even buildings under construction 33% considered the impact of this menace as moderate while the second majority (31%) believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to design errors and modification (Figure 6).



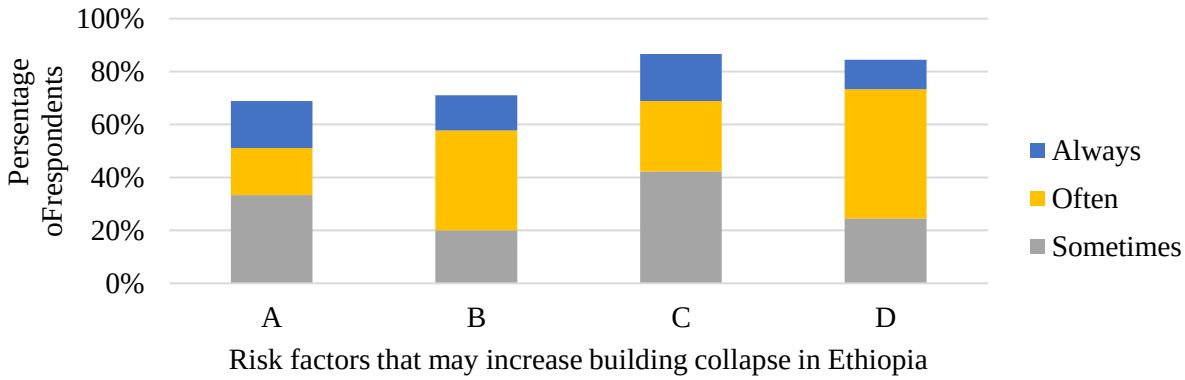
Key	Text
A	Structural Engineer design error
B	Project Manager failed to detect and challenge structural design error
C	Site Engineer of contractor failed to detect and challenge structural design error
D	Site supervisor of consultant failed to detect and challenge structural design error
E	Owner request for design modifications after significant works are already started that may risk structural integrity
F	Structural Engineer approval for design modifications after significant works are already completed
G	Supervisor failed to challenge new proposal for design modifications after significant works are already completed

Figure 4.3. Frequency of design error in building collapse in Ethiopia

4.4.4 Role of material quality

Building Material are the basic attributes required for sustainability during load application which include strength stress/strain, ductility, durability and shrinkage Material especially reinforcement rods, steel sections and cement can contribute immensely to failure of buildings. Other substandard materials can also contribute to failure of buildings. Use of low quality materials is one of the major causes of structural failure. Collapse is a state of complete failure, when the structure has literally gives way and most members have caved-in, crumbled or buckled; the building can no longer stand as originally built thereby leading to the inability of the structure to perform its intended functions. It was gathered from the literatures that sub-standard building materials, poor workmanship, faulty design, lack of skill as well as lack of proper supervision as the main causes of building failure and collapse in Ethiopia.

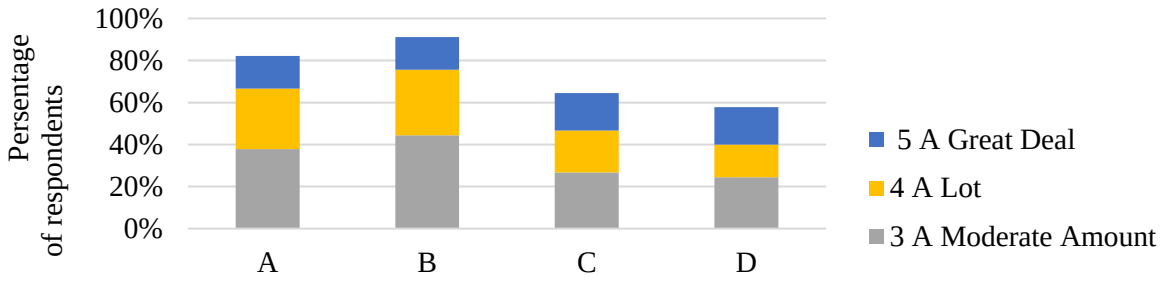
Frequency of material quality in building collapse issues of building collapse. The survey revealed that over 49% disclosed that buildings fail and collapsed „often" while the remaining majority (31%) believed it does but „sometimes". Buildings collapse in Ethiopia is not just limited to buildings in operation but even buildings under construction 44% considered the impact of this menace as moderate while the second majority (33%) believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to material quality describe the chart below



Key	Text
A	Supervisor failed to investigate the appropriate quality materials for construction at site
B	Site Engineer of Contractor lacks experience to detect substandard materials
C	Contractor Site Engineer failed to report substandard materials for construction
D	Project manager/Owner forced the subcontractor to use low quality material

Figure4.4. Frequency of material quality in building collapse in Ethiopia

Relevance of material quality in building collapse in Ethiopia The survey revealed that over 49% disclosed that buildings fail and collapsed „often" while the remaining majority (31%) believed it does but „sometimes". Buildings collapse in Ethiopia is not just limited to buildings in operation but even buildings under construction 44% considered the impact of this menace as moderate while the second majority (33%) believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to material quality describe the chart below



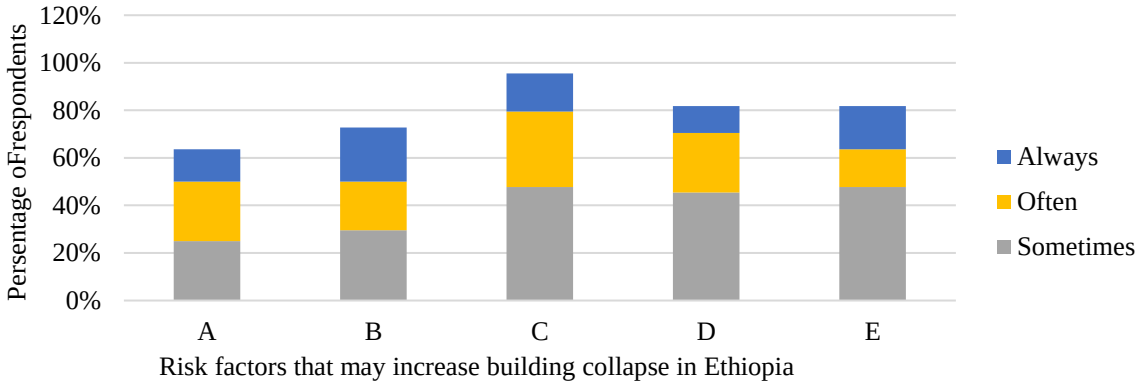
Key	Text
A	Supervisor failed to investigate the appropriate quality materials for construction at site
B	Site Engineer of Contractor lacks experience to detect substandard materials
C	Contractor Site Engineer failed to report substandard materials for construction
D	Project manager/Owner forced the subcontractor to use low quality material

Figure 4.5. Relevance of material quality in building collapse in Ethiopia

4.4.5 Role of workmanship and work methodology

Workmanship is skill quality put into making product or completing a project the failure of building structure are due to workmanship negligence the lack of effort put into quality control processes of your construction site. The quality of the workmen is a measure of their effectiveness and efficiency at all times during construction while the level of building maintenance after its occupation depends on the performance of workmen. Poor workmanship causes incorrect water to cement ratio, improper plumbing poor concrete compaction installing product $material incorrectly. Some result of poor workmanship: moulding corrosion damage electric wire injuries and death loss of water through evaporation crack I foundation and wall leaking roof plumbing issues.

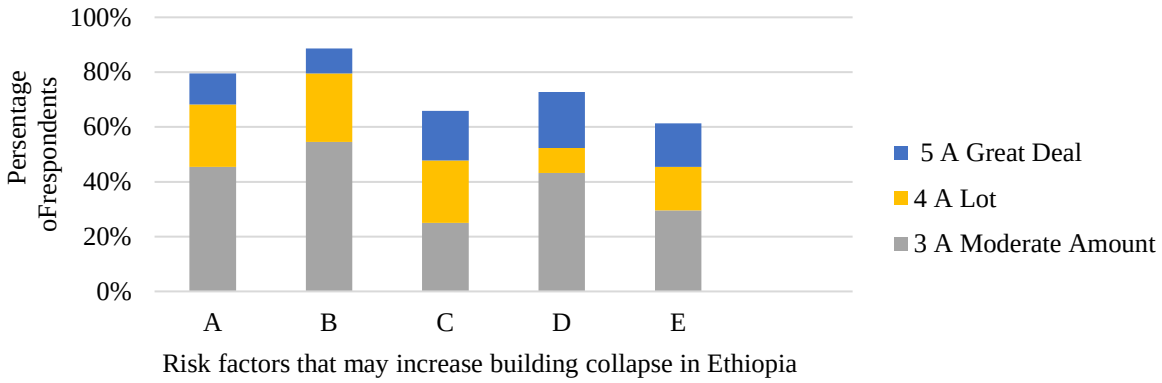
Frequency of workmanship and work methodology in building collapse in Ethiopia. The survey revealed that over 55% disclosed that buildings fail and collapsed „often“ while the remaining majority (32%) believed it does but „sometimes“. Buildings collapse in Ethiopia is not just limited to buildings in operation but even buildings under construction 45% considered the impact of this menace as moderate while the second majority (55%) believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to Poor workmanship.



Key	Text
A	Consultant's supervisor doesn't have the knowledge/skill/experience with work methodology to guide works
B	Consultant's supervisor failed to detect problems on contractors work methodology
C	Employing poor workmanship to save money
D	Contractor site Engineer do not have experience on how to implement or manage works to the required standard
E	Project manager / owner forced the contractor to use poor construction method either as a part of the agreement or other issues

Figure 4. 6. Frequency of workmanship and work methodology in building collapse in Ethiopia

Relevance of workmanship and work methodology in building collapse in Ethiopia The survey revealed that over 55% disclosed that buildings fail and collapsed „often“ while the remaining majority (32%) believed it does but „sometimes“. Buildings collapse in Ethiopia is not just limited to buildings in operation but even buildings under construction 45% considered the impact of this menace as moderate while the second majority (55%) believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to Poor workmanship.



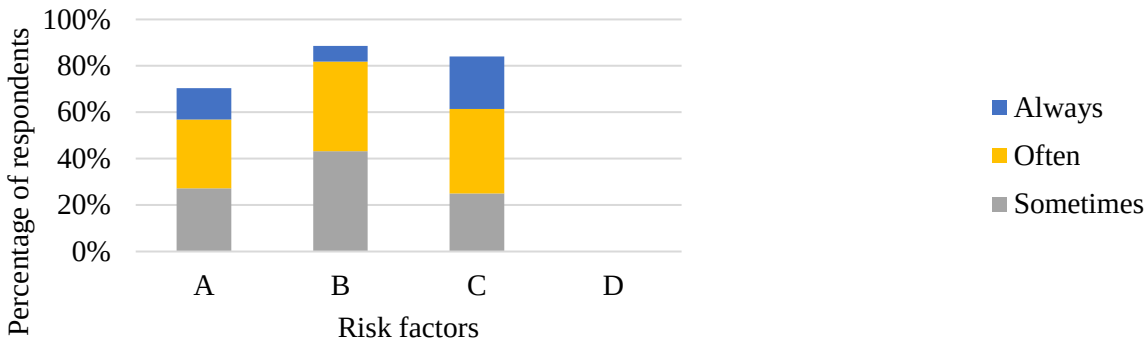
Key	Text
A	Consultant's supervisor doesn't have the knowledge/skill/experience with work methodology to guide works
B	Consultant's supervisor failed to detect problems on contractors work methodology
C	Employing poor workmanship to save money
D	Contractor site Engineer do not have experience on how to implement or manage works to the required standard
E	Project manager / owner forced the contractor to use poor construction method either as a part of the agreement or other issues

Figure 10. Relevance of workmanship and work methodology in building collapse in Ethiopia

4.4.6 Role of geotechnical issues

Geotechnical properties of soils influence the stability of civil engineering structures. Most of the geotechnical properties of soils influence to each other. Sites lacking of geotechnical investigation study not following or lack of understanding of geotechnical investigation report Approval of foundation level on poor soil structure.

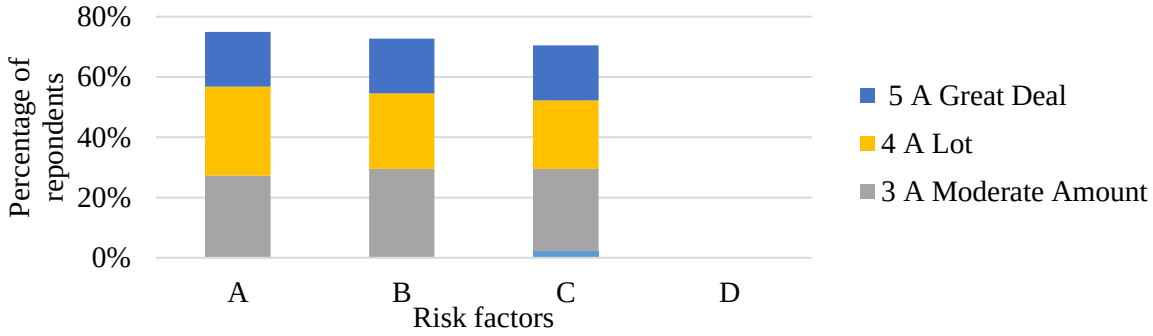
Frequency of geotechnical issues in building collapse in Ethiopia The survey revealed that over 39% disclosed that buildings fail and collapsed „often“ while the remaining majority (30%) believed it does but „sometimes“. Buildings collapse in Ethiopia is not just limited to buildings in operation but even buildings under construction 43% considered the impact of this menace as moderate while the second majority (30%) believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to geotechnical issues.



Key	Text
A	Project lacking geotechnical investigation study
B	Not following or lack of understanding of geotechnical investigation report
C	Approval of foundation level on poor substructure

Figure 11. Frequency of geotechnical issues in building collapse in Ethiopia

Relevance of geotechnical issues in building collapse in Ethiopia The survey revealed that over 43% disclosed that buildings fail and collapsed „often“ while the remaining majority (30%) believed it does but „sometimes“. Buildings collapse in Ethiopia is not just limited to buildings in operation but even buildings under construction 39% considered the impact of this menace as moderate while the second majority (30%) believed to have major impact. Below are charts describing the frequency and the impact of the collapsed due to geotechnical issues describe the chart below.



Key	Text
A	Project lacking geotechnical investigation study
B	Not following or lack of understanding of geotechnical investigation report
C	Approval of foundation level on poor substructure

Figure 12. Relevance of geotechnical issues in building collapse in Ethiopia

5 Discussion

The main aim of this paper was to identify the most frequent factor that contribute building collapse in Ethiopia. From results of the questioner survey, poor workmanship, faulty design, lack of skill, sub-standard building materials, as well as lack of proper supervision as the main causes of building failure and collapse in Ethiopia.

Concern over material quality is ranked 1st cause of building failure followed by workmanship and work methodology. For contribution factors to building collapse and failures, the highest rated factor is construction materials and lack of skill with the highest value that sub-standard building materials is amongst the causes the major materials (reinforcement steel, structural steel and cement). Lack of proper construction supervision is rated the most substantial cause followed by construction process and monitoring/enforcement.

Inappropriate construction equipment (85%) and bankruptcy of contractor or owner (80%) have a moderate to great deal of contribution to building structural failure in Ethiopia respectively. Faulty during construction or poor workmanship is one of the popular factor that lead to building failures problems. They are structurally important to the permanence of a building and should not be lacking, usually residential buildings are the one which experienced most of the failures problems due to poor workmanship. Workmanship is skill quality put into making product or completing a project the failure of building structure are due to workmanship negligence the lack of effort put into quality control processes of your construction site Poor workmanship Problems are closely related to the developer and also the contractor that construct the buildings.

Contractor Site Engineer failed to report substandard materials for construction (82%) and project manager forced the subcontractor to use low quality material (81%) have a sometimes to always of contribution to building structural failure in Ethiopia respectively. collapse Construction material is an important because the materials being used in construction will determine the behaviour of the structure and resulted in any types of failures in the future. Sometimes the usage of materials that are not according to specification is the consequence from irresponsible parties who intentionally reduce the quality in order to reduce the cost.

Structural Engineer design error (75%) and Supervisor failed to challenge new proposal for design modifications after significant works are already completed (70%) have a moderate to great deal of contribution to building structural failure in Ethiopia respectively. faulty design, building type and change in use causing collapse of buildings in Ethiopia. This type of buildings rarely being change into other types of building such as goods storage or building that holds greater load than it is supposed to handle. Moreover, it is rarely seen that building is being change for other usage other than what it is designed.

Consultant's supervisor doesn't have the knowledge/skill/experience with work methodology to guide works (79%) and Consultant's supervisor failed to detect problems on contractors work methodology (82%) have a moderate to great deal of contribution to building structural failure in Ethiopia respectively. poor supervision is simultaneously linked with inability to inspect building materials used in producing the critical building/structural elements (foundation, column, beam and slab; whose determine the building stability; and their failure is amount to building failure and consequently Reducing the quality of materials and also the cost seem to have a hidden agenda among the parties involved.

A Project lacking geotechnical investigation study (78%) and B Not following or lack of understanding of geotechnical investigation report (75%) have a moderate to great deal of contribution to building structural failure in Ethiopia respectively. Finally three major factors responsible for building collapse were identified first one is poor material quality, second poor workmanship and work methodology, third is design error.

6 Conclusions & Recommendations

6.1 Conclusions

The objectives of this research were to confirm the most significant causes of building failure and collapse in Ethiopia. The research had been achieved based on the literature review from articles, journals and books; findings from questionnaire survey. Building collapse has very high effect on human lives and property and as a result of personal greed of many developers. There should therefore be a review of existing building laws that should guide standard code of practice

The finding has justified that use of sub-standard (poor) building materials is still a major cause of building collapse. The findings ascertained that steel reinforcement, structural steel and cement as the major building materials contributing to building collapse.

Three major factors responsible for building collapse were identified. Firstly, construction materials and lack of skill experiences of workers directly engaged in different parts of the project work were found linked with cost. Secondly, poor project management scheme among client, contractor and consultant. Finally, design error failed to detect and challenge structural. Owner request for design modifications after significant works are already started that may risk structural integrity Structural Engineer approval for design modifications after significant works are already completed Supervisor failed to challenge new proposal for design modifications after significant works are already completed.

It may be concluded that the professionals‟ views directed to civil/structural engineering aspect of building works in terms of lacking proper supervision supervisor failed to detect problems on contractors work methodology. Hence, civil/structural engineers (at design and construction) are fully responsible for managing the production of structural elements and quality of the materials used in producing these elements for building stability. Form questioner survey the officer of the client, project manager and resident engineer from contractor and consultant side respectively reported poor quality material usage as a major cause over poor workmanship.

6.2 Recommendations

Collapse of buildings cannot be totally eradicated but can be minimized if public emotions can be played down and the press can lay more emphasis on educating the public at large on the dangers of the collapse of a building. The following intervention areas identified and recommended in order to decreases problems which lead to building collapse in the construction industry Based on the findings of this study

Proper planning, supervision and monitoring of construction activities should be institutionalized by policy makers to ensure that all buildings are constructed according to design, specifications and planning regulations.

- Professionals in the building industry should maintain their integrity and professional values.
- Avoid using building that mean for Residential use as Commercial. As we understand that Residential building cannot withstand intensive use and human traffic.
- Foundation of building should be taken into consideration before putting load.
- Building professionals should ensure to carryout proper and efficient supervision of works on site
- Government should ensure that before any work commence on site, the materials to be used must be stamped by various professionals working on the site
- Soil investigation, material tests should be made compulsory for all institutional, industrial and commercial building

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Appendix

Appendix A: Research questioner used for the study

Dear respondent

This questionnaire prepared to obtain necessary data for the partial fulfilment of a BSC thesis in Civil Engineering. The objective of this thesis is to assess factor that increases risk of building collapse (structural failure). Hence I kindly request you to respond to the questions. I would like to confirm that the information you provide me will be kept strictly confidential and will not be shown to other persons.

Part I: General Information

1. Your highest educational achievement _____
2. Do you have a working experience in the construction Industry? a) Yes b) No

   If your answer to question number 2 is yes,
3. Type of organization you have worked
   a) Client b) Consultant c) Contractor d) Other _____
4. Class of your organization _____
5. Your position on this site _____
6. How many years of experience (in the construction industry) _____
7. From your experience, please list factors that may contribute to building structural failure in Ethiopia?

_____

Part II: Relevance of risk factors contributing to building collapse (Partial or complete failure of building structural elements)

How significant are the contribution of following factor to failure of structural elements?		Not at all 1	A little 2	A moderate amount 3	A lot 4	A great deal 5
1	Poor project management					
2	Unsuitable construction materials					
3	Inadequate time					
4	Lack of experience					
5	Inappropriate construction equipment					
6	Complicated role of subcontractor					
7	Lack of skill					
8	Bankruptcy of contractor or owner					
9	Corruption and fraud					

How significant are the contribution of following factor to failure of structural elements?		Not at all 1	A little 2	A moderate amount 3	A lot 4	A great deal 5
1	Structural Engineer design error					
2	Project manager of Owner failed to detect and challenge structural design error.					
3	Site Engineer of Contractor failed to detect and challenge structural design error					
4	Site Supervisor of consultant failed to detect and challenge structural design error					
5	Owner request for design modifications after significant works are already started that may risk structural integrity.					
6	Structural Engineer approvals for design modifications after significant works are already completed.					
7	Supervisor failed to challenge new proposal for design modifications after significant works are already completed.					
8	Supervisor Failed to investigate the appropriate quality of materials for construction at site using appropriate					

9	Site Engineer of Contractor lacks experience to detect substandard materials					
10	Contractor site Engineer failed to report substandard materials for construction					
11	Project manager/owner forced the contractor to use low quality material					
12	Consultant's supervisor doesn't have the knowledge/skill/experience with work methodology to guide works					
13	Consultant's supervisor failed to detect problems on contractors work methodology					
14	Employing Poor workmanship of to save money					
15	Contractor site Engineer does not have experience how to implement or manage works to the required standards.					
16	Project manager/owner forced the contractor to use poor construction method either as a part of the agreement or other issues					
17	Sites lacking of geotechnical investigation study					
18	Not following or lack of understanding of geotechnical investigation report					
19	Approval of foundation level on poor soil structure					

Part III: Frequency of risk factors that may increase risk partial or complete structural failure of buildings.

How frequently are the following factors in building construction projects?		Never 1	Rare 2	Sometimes 3	Often 4	Always 5
1	Structural Engineer design error					
2	Project manager of Owner failed to detect and challenge structural design error.					
3	Site Engineer of Contractor failed to detect and challenge structural design error					
4	Site Supervisor of consultant failed to detect and challenge structural design error					

5	Owner request for design modifications after significant works are already started that may risk structural integrity (e.g. request for additional floor)					
6	Structural Engineer approval for design modifications after significant works is already completed.					
7	Supervisor failed to challenge new proposal for design modifications after significant works are already completed.					
8	Supervisor Failed to investigate the appropriate quality of materials for construction at site using appropriate					
9	Site Engineer of Contractor lacks experience to detect substandard materials					
10	Contractor site Engineer failed to report substandard materials for construction					
11	Project manager/owner forced the contractor to use low quality material					
12	Consultant's supervisor doesn't have the knowledge/skill/experience with work methodology to guide works					
13	Consultant's supervisor failed to detect problems on contractors work methodology					
14	Employing Poor workmanship of to save money					
15	Contractor site Engineer do not have experience how to implement or manage works to the required standards.					
16	Project manager/owner forced the contractor to use poor construction method either as a part of the agreement or other issues					
17	Sites lacking of geotechnical investigation study					
18	Not following or lack of understanding of geotechnical investigation report					
19	Approval of foundation level on poor soil structure					