

Causes of Failure and Collapse of Building Structures in Cameroonian Cities

Théodore Gautier L.J. Bikoko¹, Jean Claude Tchamba²

¹*Department of Civil Engineering Science, University of Johannesburg, PO BOX 524, Auckland Park, Johannesburg, South Africa, lejeunegautier@rocketmail.com*

²*Department of Civil Engineering, ENSET, University of Douala, PO BOX 1872, Douala, Cameroon*

ABSTRACT. *The phenomena of failure and consequent collapse of building structures in Cameroonian cities is so common that it has become a serious concern to the professionals in the building industry, clients, governments, and general public. In most cases, the architects and engineers who are directly involved in the construction of such building are held responsible for building collapse. This paper is intended to find out the causes of building failure and collapse in Cameroonian cities. Based on personal experience of the authors and also data collected through academic journals, conference proceedings, media reports, internet, and previous works of other authors on the subject matter, the reasons or causes of failure and collapse of building structures in the country are: Use of sub-standard construction materials or use of low quality building materials, wet-dry cycling, use of quacks or artisans, neglect of design and non-possession of approved drawings or non-possession of building permits, inadequate preliminary works which include inadequate site investigation and foundation, the lack of follow-up by the local authorities after the issuance of the building permit, constructions in swampy areas, heavy rain, design errors/faulty design, erosion, cavitation, abrasion, lack of qualified supervision and unused equipment at building sites, poor materials and workmanship, lack of equipment in the construction industry, faulty construction methodology, illegal conversion of building, change of use of buildings, financial pressures, lack of quality control check, fire disaster, poor management and maintenance in buildings, corrosion of the reinforcement bars, amongst others. The paper concludes by suggesting measures to reduce or minimize or limit building accidents in Cameroon.*

KEY WORDS: *Building, Collapse, Failure, Cameroonian Cities.*

1. Introduction

The problems of failure and consequent collapse of building structures in Cameroonian cities are common phenomena and becoming more and more serious and in most cases result in loss of human lives and civil engineering structures. The failure and collapse of structural buildings is a subject of paramount importance and are of global concerns. The collapse of a structural building is not predictable but when it fails, it usually causes several deaths and injuries. Some of the incidents of collapsed buildings that have occurred within the past around the world include: the Ronan Point apartments collapse in UK when kitchen gas exploded on the 18th floor sending a 25-storey building to the ground in 1968, the 2000 Commonwealth Avenue Tower collapse in Boston, USA in 1971, the collapse of Murrah Federal Building in Oklahoma City in 1995, where air blast pressure caused the collapse of few lower floors while the upper floors failed by progressive collapse. On 29 March, 2008 in Luanda, Angola, a six-storey police building collapsed with detainees. In year 2000, a four-storey commercial building at 14th and 2nd Avenue in Brooklyn, USA, collapsed and vacant building at 124th Street in the north of Manhattan in New York, USA partially collapsed in 2007. The collapse of a six-storey guesthouse at the Lagos church complex of TB Joshua, Nigeria in September, 2014, killing 116 people- 84 of them South Africans. The collapse of a five-storey building in Mumbai, India, killing at least 61 people and 32 others were injured. In February 26, 2010, a five-storey residential building under construction collapsed at Nkolndongo, the suburb of Yaoundé, Cameroon, where 4 deaths were recorded [TCH 16]. In June, 2016, a two-storey building under construction collapsed at Ndokoti, the suburb of Douala, Cameroon, killing at least 4 people. In September, 2015, a five-storey building under construction collapsed at Nkongmondo, the suburb of Douala, Cameroon. In year 2006, a church collapsed upon the congregation during a service at Kalerwe, a Kampala city suburb, Uganda, killing 27 people and 86 serious injuries [ALI 14]. The collapse of the Versailles Wedding Hall in Jerusalem, Israel's where 23 deaths and 380 injuries were recorded; the collapse of the Hyatt Regency at a tea dance in Kansas City, Missouri, USA, killing 114 people and 200 injuries; the collapse of the 5-story Sampoong

Department Store in the Seocho District of Seoul, South Korea, where 502 deaths were reported. In April, 2013, a Rana Plaza textile factory building collapse in Dhaka District, Bangladesh, killing 1129 people and 2515 others were injured (Figure 1). In April, 2016, a six-storey building collapse in Nairobi, the Kenyan capital, killing 50 people, the investigation found that the building was not have building permit.



Figure 1. The collapse of Rana Plaza textile factory building [BOA 18]

At present, there is little data or information available in Cameroon on building accidents, and more data are needed. This paper is intended to find out the causes of building failure and collapse in Cameroonian cities. The paper also suggests measures to reduce or minimize or limit building accidents in Cameroon.

2. Method of Study

This paper is based on personal experience of the authors and also some data were collected through academic journals, conference proceedings, media reports, internet, and previous works of other authors on the subject matter. Through this, the reasons or causes of failure and collapse of building structures in the country can be summarized as follows :

3. Reasons or causes of failure and collapse of building structures in Cameroonian cities

- Use of sub-standard construction materials or use of low quality building materials

The materials used in the construction of civil engineering infrastructures play a significant role in the durability of concrete structures. According to Neville [NEV 10] (cited in Tchamba and Bikoko (2016)), concrete is any product or mass made by the use of a cementing medium, and this medium is the product of reaction between hydraulic cement and water. They also consider concrete no more than a mixture of cement as binder, water, aggregate (fine and coarse) and admixtures (chemical or mineral or both) [NEV 10] . Admixtures are chemical or mineral or both. Mineral admixtures included slag, silica fume, fly ash or pulverized-fuel ash, rice husk ash, metakaolin, amongst others and chemical admixtures included superplasticizer, water reducer, amongst others. Admixtures are used to improve the performance of the concrete. Concrete is the manufactured construction material more known and more used in Cameroon.

Cements used in construction in Cameroon are cements produced by Cimencam of three different cement strength classes which are 32.5, 42.5 and 52.5 and several varieties of imported cements. The problems at this level are storage, storage conditions and smuggling. According to investigation conducted by the Cameroonian Civil Engineering Laboratory (LABOGENIE), imported cements lose 15 to 20% of their strength from the period of manufacture to that of use. Increased storage conditions at different points of sale and time to market that are never respected; the contractor is always with a product whose use can't meet the required formulations.

Most of the aggregates used in construction in Cameroon are of poor quality. These are alluvial sands; the quarry

sands have not been subjected to any quality control test, no appreciation from any expert and which unfortunately are used as constituents of concrete. Gravel is pebbles collected here and there of unknown resistance and especially with flattening coefficients very high and whose sizes are not always defined.

The water used in the manufacturing of concrete doesn't contain harmful elements and impurities in such quantities that they could adversely affect the setting, hardening and durability of the concrete. The mixing water used in the manufacturing of concrete is often of unknown origin, some are acidified and some are full of plant and organic debris. The poor quality of cement, sand, gravel, mixing water used in the manufacturing of concrete in Cameroon make poor quality concrete and therefore leading to building failure and collapse.

- Wet-dry cycling

Repeated cycles of wet / dry cause dimension changes in the concrete that can create cracks and therefore promote the penetration of aggressive agents through the cracks and pore spaces causing the corrosion of steels if moisture is present and consequently collapse of the structure.

Concrete is subject to significant dimension changes when its temperature and hygrometry change. The desiccation of fresh concrete leads to a contraction that produces shrinkage phenomenon. Then, any humidification or temperature rise caused an expansion. In areas exposed to the sun or humidity, the alternation of these two phenomena causes cracking.

Figure 2 shows the action of alternating wet / dry cycles on poorly vibrated concrete.



Figure 2. Cracks due to alternating wet / dry cycles (Photo Bonapriso, 2014)

- Use of quacks or artisans, neglect of design and non-possession of approved drawings or non-possession of building permits

Before commencing the construction of a permanent building on a site within the city, its architectural drawings such as the site plan, the floor plans, the cross section plans, detail drawings, the elevation views, the foundation plan, the roof plans, etc. structural drawings such as the reinforcement plans of the various structural elements (columns, beams, footings, slabs, staircase, etc.), as well as its bill of quantities and estimated cost of construction are normally submitted to the approval of local authorities (the municipal authorities or city or town council authorities) by a Registered Professional Engineer. Normally, these documents should be prepared by a Registered Architect and/or Professional Engineer. Construction works done without undertaking this approval process would be considered illegal.

The results of the surveys conducted support previous studies by the Ministry of Urban Development and Housing (Minduh) (1990) and Pettang [PET 93] (Cited in Epindepinde, 2014) respectively, indicating that more than 90% of dwellings in Yaoundé were without building permits and 800,000 inhabitants of the political capital at that time had not consulted even a single building expert during the execution of their constructions. The Nzemen [NZE 98] (Cited in Epindepinde, 2014) and Mouafo [MOU 86] (Cited in Epindepinde, 2014) reports showed that 1200,000 inhabitants of Douala built their houses without the consultation of building experts

(Architect and/or Professional Engineer), i.e. more than 80% of the population accommodated. Figure 2 and Figure 3 show respectively that the Emombo neighborhoods in Yaoundé and Bépanda in Douala are the poorer neighborhoods where housing supply is the poorest and the percentage of buildings lacking building permits or administrative documents is the highest.

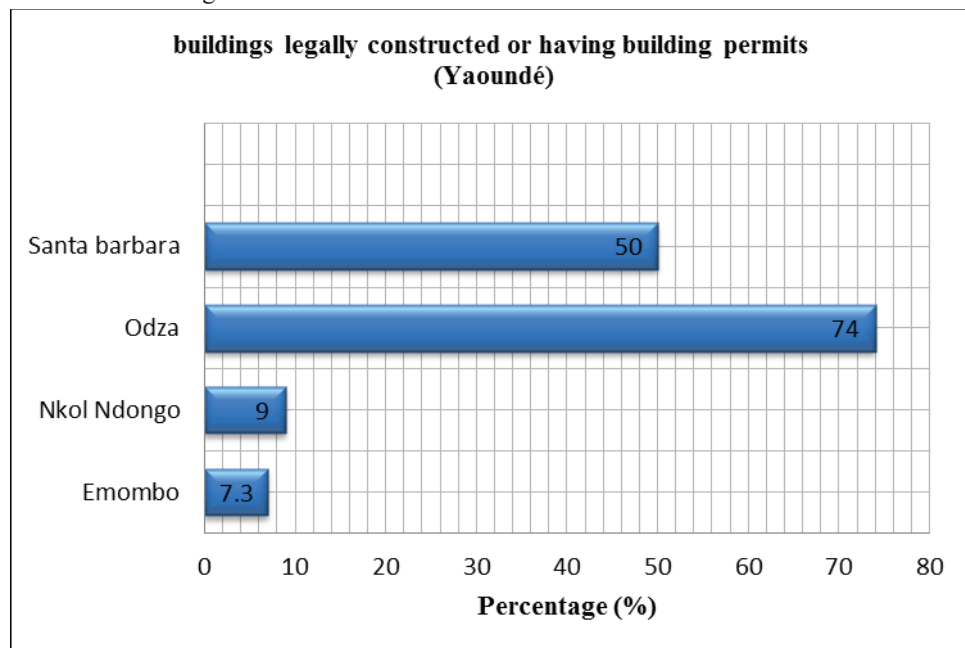


Figure 3. Percentages of buildings legally constructed or having building permits in certain suburbs in the city of Yaoundé [TCH 16]

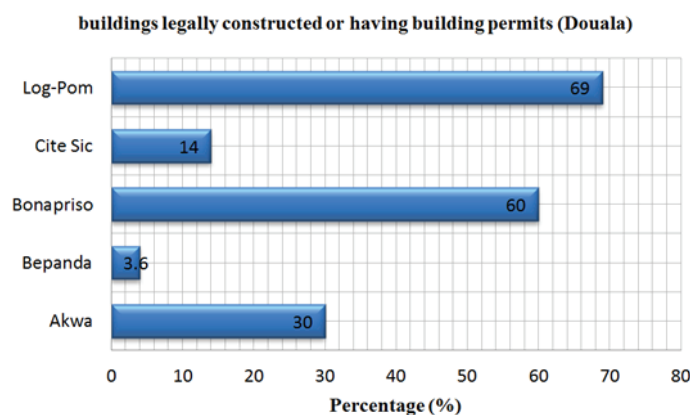


Figure 4. Percentages of buildings legally constructed or having building permits in certain suburbs in the city of Douala [TCH 16]

Additionally, other factors identified included:

- Inadequate preliminary works which include inadequate site investigation and foundation.
- The lack of follow-up by the local authorities after the issuance of the building permit
- Constructions in swampy areas
- Heavy rain
- Design errors/Faulty design (Figure 5)
- Erosion (Figure 6)
- Cavitation
- Abrasion
- Lack of qualified supervision and unused equipment at building sites

- Poor materials and workmanship (Cut costs by contractors by using incorrect materials and employing unskilled workers who are cheaper than trained builders)
- Lack of equipment in the construction industry
- Faulty construction methodology
- Illegal conversion of building
- Change of use of buildings
- Financial pressures
- Lack of quality control check
- Fire disaster
- Poor management and maintenance in buildings
- Corrosion of the reinforcement bars (Figure 7). Figure 7. Shows cracking, spalling, and brownish staining on a part of building elements in Yaoundé which are symptoms of reinforcement corrosion. The possible causes of cracking and spalling are poor workmanship during the construction phase. The corroded reinforcements at these elements is the possibly the result of their expositions to the environment (carbon dioxide attack, acidity of rain water, etc.).
- Others



Figure 5. Collapse site of a 4-storey building at Nkoldongo, Yaoundé due to design errors
<http://fr.africanews.com/2016/06/20/cameroun-cinq-morts-dans-l-effondrement-d-un-immeuble/>



Figure 6. Foundation failure due to Erosion [TCH 16]



Figure 7. Cracking, spalling, and brownish staining due to corrosion of the reinforcement bars

4. Conclusion

This paper reports the causes of building failure and collapse in Cameroonian cities. Based on personal experience of the authors and data collected through academic journals, conference proceedings, media reports, internet, and previous works of other authors on the subject matter, the reasons or causes of failure and collapse of building structures in Cameroonian cities are: Use of sub-standard construction materials or use of low quality building materials, wet-dry cycling, use of quacks or artisans, neglect of design and non-possession of approved drawings or non-possession of building permits, inadequate preliminary works which include inadequate site investigation and foundation, the lack of follow-up by the local authorities after the issuance of the building permit, constructions in swampy areas, heavy rain, design errors/faulty design, erosion, cavitation, abrasion, lack of qualified supervision and unused equipment at building sites, poor materials and workmanship (cut costs by contractors by using incorrect materials and employing unskilled workers who are cheaper than trained builders), lack of equipment in the construction industry, faulty construction methodology, illegal conversion of building, change of use of buildings, financial pressures, lack of quality control check, fire disaster, poor management and maintenance in buildings, corrosion of the reinforcement bars, amongst others.

Based on our analysis, it can be concluded that the causes of building failure and collapse in Cameroonian cities fall into six general areas, namely design deficiencies, material deficiencies, construction deficiencies, administrative deficiencies, maintenance deficiencies and environmental related problems.

5. Recommendations

The following measures would aid to reduce or minimize or limit building accidents in Cameroon:

- The Cameroonian National Order of Civil Engineers (ONIGC), National Order of Architects (ONAC), National Order of Urbanists and Geoscientists, should ensure that only registered and qualified professionals are involved from design stage to completion stage in the construction of future buildings
- Proper preliminary works which include proper site investigation and foundation
- Getting approval before commencing construction on site,
- Inspection of construction site should be enforced at the local government authorities and relevant government departments to ensure compliance with approved building plans.
- Proper and stronger supervision should be provided on the part of the building professionals
- Efficient checking of materials before using them into construction works

6. References

[ALI 14] ALINAITWE, H. M., EKOLU, S.O., «Failure of Structures in East Africa with focus on the causes of failures in the construction phase ». In: S.O. Ekolu et al. (Eds) *Proceedings of the First International Conference on Construction Materials and Structures*, 24-26 November, Johannesburg, South Africa, 2014, pp. 76-85

- [TCH 16] TCHAMBA, J.C., BIKOKO, T.G.L.J., «Failure and Collapse of Building Structures in the Cities of Yaoundé and Douala, Cameroon from 2010 to 2014», *Modern Applied Science*, Vol. 10, No. 1, 2016, pp. 23-33
- [EPI 14] EPINDEPINDE, L. R., ETOUNDI NDEMEZO'O, F.Y., NWAHA SAHBA, H. S., « Étude Statistique Des Causes de La Dégradation Précoce Et De L'effondrement Des Bâtiments Dans Les Villes De Douala Et Yaoundé : Période allant de 2010 à 2014», Memoire de DIPET II, Juin 2015, Université de Douala, ENSET, Douala, Cameroun
- [NEV 10] NEVILLE, A. M., BROOKS, J. J., «Concrete Technology» (2nd ed.). Longman Group, 2010, UK publishers Ltd.
- [BOA 18] BOATENG, F.G., «Exploring the collapse of buildings in urban settings». *Proceedings of the Institution of Civil Engineers –Municipal Engineer*, 2018, pp. 1-9, <https://doi.org/10.1680/jmuen.17.00033>
<http://fr.africanews.com/2016/06/20/cameroun-cinq-morts-dans-l-effondrement-d-un-immeuble/>