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Development Control Regulations Compliance: Paradigm Change to Reinvent Disrupted Public Spaces and Make Future Great Place in Ado-Ekiti, Nigeria

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Abstract Public spaces in the human society predate the built environment. Settlements expanding unto open spaces necessitate statutory control to ensure orderly development and mutual existence of various land uses. In developing countries like Nigeria, public spaces are subjected to encroachment and depletion. These result from rapid urbanization, population increase and space demand for human activities. Extant development control regulations seem ineffective in Ado-Ekiti, Ekiti State capital. Illegal development into public spaces is alarming, subtracting vital greenery and environmental quality from the city. This paper assesses the state of the environment to determine the extent of encroachment, and examines causal factors. Methods includes the review of existing planning laws pertaining to the establishment and maintenance of setbacks, open spaces and parks; and other related issues from literature sources. Questionnaire administration, interviews, focus group discussions and direct observation in selected city districts generated primary data. Findings reveal deplorable state of the environment occasioned by audacious encroachment of public spaces mainly by informal commercial activities. Ignorance of good quality environment, lack of effective governmental control, and people's desire for economic benefits are among factors responsible for these public spaces disruption. The research establishes that the city is devoid of greenery, while aesthetics, environmental quality, mobility, health, and livability are adversely affected. It is recommended that the State Government and municipal authority should strictly enforce extant statutory development control laws to reclaim lost socio-cultural spaces and revitalize urban green places. Functional 'trading/market' places should be incorporated into some of these spaces as development solution for informal sector economic activities, and thereby cater for the needs of itinerant traders and the urban populace. These measures, guided by a well-structured green city master plan, guarantee the return of the greens and biodiversity into the cityscape, and also provide avenues for making future sense of a great place in Ado-Ekiti, the fledging capital city of Ekiti State, Nigeria.

Keywords Public Spaces, Lost Spaces, Reclamation, Greening, Placemaking, Inclusiveness

1. Introduction

Public spaces are integral components of human settlements from time immemorial. According to Fadamiro (2002), these include street space, park system, and the entire larger space in which the city exists. Public spaces are known to enhance urban design, civic identity, community cohesion, and quality of life (Sustasis Foundation, 2016). However, rapid urbanization has deprived cities of valuable public spaces and their inherent benefits. The spate of amorphous city expansion appears to have defied statutory control measures in Nigeria. Ojo-Fajuru and Adebayo (2016) confirm in Ado-Ekiti, in the southwestern geopolitical zone of Nigeria, that byelaws and regulations for guiding developmental processes are deemed ineffective, given the incidences of public space invasion and succession induced by non-compliance with due process, culminating to lost spaces. The warning of John Paul II (1979), that people shun sustainability and often tend 'to see no other meaning in their natural environment than what serves for immediate use and consumption', is already manifested in the contestation and personal aggrandizement of public spaces in the city. The incessant encroachment on public open spaces, squares, parks, setbacks and carriageways has led to the disappearance of greenery, which has eroded the quality of urban design and aesthetics in the capital city.

The paper discusses the importance of public spaces as they are well known all over the world so as to accentuate the inadequacy or total lack of these spaces in Ado-Ekiti. It

is intended to explore the significance of such public spaces and the need to fill existing gaps and transform the city.

It is therefore deemed necessary to assess the existing state of the urban environment to determine the extent of encroachment on public open spaces, and the level of compliance with statutory provisions on development control in the city. This is intended to make a case for strict compliance with extant enactments, and reclaim disrupted public spaces for the reestablishment of green areas befitting of a state capital. Eventually, these measures will revive verdant and pleasurable places that are guaranteed to improve environmental quality, recreational potentialities, and livability, to reinvent Ado-Ekiti as world class Nigerian city of the future.

2. Literature Review

Planning laws are rules, regulations, statutes, byelaws, edicts and codes enacted to guide the trend of development to ensure conformity of land use activity, and promote order, efficiency, health, economy, convenience, safety and wellbeing in a particular place over a long period of time. Gray (2011) generalizes that environmental law as a body of laws, which seeks to protect or enhance the environment. Taking cue from the British Planning law, Section 91 of the Nigerian Urban and Regional Planning Law, Decree 88 of 1992 interprets development as the carrying out of any building, engineering, mining or other operations in, on, over or under any land, or the making of environmentally significant change in the use of any land or demolition of building including the felling of trees and the placing of free-standing erections used for the display of advertisements on the land, and the expression 'develop' with its grammatical variation shall be construed accordingly (Federal Government of Nigeria, 1992). This definition is replicated in Ekiti State Urban and Regional Planning and Development Law, No.16 of 2011, in which development translates to the carrying out of any building, mining or other operation in, on, over or under any land; or the making of any material change in the use of any land, building or structure, or conversion of land, building or structure from its established or approved use; or placement or display of urban furniture on the land, on building or structures; or making of any environmentally significant change in the use of any land, and demolition of buildings including the felling of trees (Ekiti State Government, 1997). The implication is that any particular operation or change of use that falls within the realm of development requires planning permission, indicating that any development that does not have the planning permission of the relevant planning agency constitutes illegal development (NITP, 2014).

Ojo-Fajuru and Olaseni (2015) disseminate development control is the process of implementing approved planning standards and regulations to ensure that development is carried out in accordance with approved planning standards and statutory provisions. In the United Kingdom, development control (DC), planning control, or development management (as it is known in Scotland) is the aspect of town and country planning that utilizes various categories of public-spirited plans, as reference documents, to grant or refuse planning permission aimed at regulating the use of land and erection of new buildings in juridical local governments. Accordingly, development control, seen as a mechanism to maintain standards (Aluko, 2011), is in line with the concept of quality control, exercised when the development taking place is guided towards attaining the physical development proposals contained in approved building plans, layout (land subdivision) schemes, or development plans. These development proposals are based on the planning standards approved by local planning authorities. Concisely, the process of implementing approved standards and regulations, with the objective of creating functionally efficient and aesthetically appealing environment, is termed development control. For development control to succeed, it is very important to ensure strict compliance with these statutory provisions in all ramifications.

Compliance is the attitude of abiding by laid down rules, regulations or norms. Legally, it is an act or process of complying with a demand or recommendation, or observance of official requirements (Law Dictionary, 2016). Within the context of this paper, compliance means conforming to a rule, such as a specification, policy, standard or law (Wikipedia, 2016a), and by extension, environmental compliance connotes conformity to environmental planning laws, regulations, standards and other requirements (Wikipedia, 2016b). Researchers find compliance becoming extremely difficult to attain in fast growing Nigerian urban centers. In a recent study, Ojo-Fajuru and Adebayo (2014) finds that both Ado-Ekiti and Akure, the contiguous capital city of Ondo State, experienced rapid growth and development. In effect, the low level of compliance is mostly attributed to population expansion and poor physical development control mechanism; hence the increasing elusiveness of what constitutes an effective compliance in the country. In his paper on the assessment of compliance to space standards for effective development control within the Lagos Metropolitan area, Aluko (2011) unveils variety of contraventions. Such include reckless shifting of building lines, construction of permanent structures, front shops and much unsightly development on road and utility setbacks, while the regulatory authorities have been foot dragging on prosecuting offenders.

In Festac Town, west of the Metropolis, research exposes numerous constraints militating against the effectiveness of development control measures, such as inadequate monitoring of development to ensure compliance with physical planning standards in respect of development permit (approval) granted. In effect, illegal

conversion of residential buildings into mixed uses, comprising mainly residential/commercial is a common occurrence. This syndrome of non-adherence to planning regulations and standards constitutes major source of master plan distortion, and hindrance to effective development control in the predominantly planned estate (Ogundele et al., 2011). Ojo-Fajuru (2012) corroborates the disconnection between the statutory provisions of some extant laws on development control and their influence on the urban landscape in Lagos Metropolis. Research findings establish majority of development not conforming to relevant sections of the Town and Country Planning (Building Plan), L.S.L.N. No. 15 of 1986 on maximum plot coverage of development on any plot of land, which should not exceed 40%, while the undeveloped portion should be devoted to landscaping and other surface treatment. Provisions of the law on general setbacks permissible, and the responsibility of developers to provide drainage and plant ornamental trees on the sidewalks abutting their properties are flagrantly contravened. Ignorance of these extant laws is manifested in spaces around buildings and structures, which are either encroached or left with scanty greenery, thereby accentuating the widening imbalance between man and nature in the metropolis.

Using Ogbomoso South Local Government, Oyo State, Nigeria as case study, Ibrahim and Toyobo (2014) assess the impact of development control on physical development planning, and discover high level of non-compliance with development control rules and regulations by developers in the area, as evident in inadequate building setbacks, airspaces, and encroachment of farmlands, among others. Enisan and Ogundiran (2014:46) identifies non-compliance with building bye-laws and regulations as the bane Nigeria's urban environment, notably in aspects of 'zoning, setbacks, building along utility lines and non-adherence to provision of adequate ventilation', which portend risk to life, environmental degradation, and aesthetical impairment. The study, which is on the implications of urban and regional planning laws on urban renewal projects carried out in Akure, capital of Ondo State, between 2007 and 2012, indicates that the level of adherence to planning standards and regulations is extremely low. The proven reality of non-conformity with extant statutory provisions in the city negates the enthusiasm for the rule of law in the state generally. Similarly, a recent study (Adebayo, Jegede & Ogundele 2015) indicates in some randomly selected local government areas in Nigeria's South-South Geo-political Zone, that the dilapidation and collapse of transportation land use infrastructure result from non-compliance with environmental laws, such as poor or lack of drainage channels along the road network, and construction of houses on natural drainage courses and floodable areas.

In Lagos Metropolis, the hydra headed issue of non-compliance piques professionals in the built environment in recent times. Observation shows that developers embark on development without recourse to approving authorities in flagrant disobedience of town planning laws and guidelines, leading to distortions in master plans of places such as Sari-Iganmu, Ikoyi, Lekki, and the encroachment into the Cowrie Creek at the Lagoon Front. Efforts of Lagos State Building Control Agency (LSBCA) in serving of necessary statutory notices including stop work order by have not deterred the developers who continued with the extension works on the existing buildings outside the statutory setback, including infringement on rights-of-way of high-tension power lines and drainage channels. This prompts the State Commissioner for Physical Planning and Urban Development to issue stern warning that 'this high level of impunity in the building industry must stop' (Alao, 2016:58).

The Ekiti State Urban and Regional Planning and Development Law No.3 of 2011 is the current planning law in use, which makes concise provisions for the establishing, controlling and maintaining setbacks and open spaces in towns and cities in the State. Rather than setting the setback requirements in terms of land use, it relates the use and development of land to conformity with stipulated minimum setbacks to developmental entities in the categories of water bodies, roadways, facilities and utilities, and other transportation routes. It is based on this premise that Section 34 subsection (a) unambiguously stipulates that one of the requirements that developers are expected to meet before planning permit is granted to commence building operation is to make provision for minimum setbacks, such as 30 metres (98.43 feet) to streams, 60 metres (196.85 feet) to rivers, and 100 metres (328.08 feet) to the edge of dams and large water bodies, purposely to safeguard life and properties from danger within the flood plains along the banks and shores of the hydrological features. The respective minimum setbacks to federal roads, state roads, and local roads are 50 metres (164.04 feet), 30 metres (98.43 feet), and 4.5 metres (14.76 feet), while the permissible minimum setbacks to low tension (domestic) power line, medium tension power line, and high tension power line are 4.5 metres (14.76 feet), 15 metres (49.21 feet), and 45 metres (147.64 feet) respectively. Telecommunications facilities such as GSM cell radio antennas, and optical fiber lines should be provided with 10 metres (32.81 feet), and 4.5 metres (14.76 feet) minimum setbacks, while utility lines including main water pipelines and underground cables should be given minimum setbacks distance of at least 15 metres (49.21 feet). Others include quarries, as well as other transportation routes like railways and gas pipelines should be setback to minimum observable distance of 100 metres (328.08 feet), 30 metres (98.43 feet), and 30 metres (98.43 feet) respectively (EKSG, 2011). In as much as these statutory requirements have implications on the availability of public open spaces, as well as the safety and security of lives and properties

along the transportation routes, fluvial channels and communication facilities, there appears as if there is low level of compliance with these regulations given the common evasion of setback spaces for informal development.

In order to ensure strict compliance with minimum setback regulations, Section 27, subsection (1) of the Ekiti State Urban and Regional Planning and Development Law No.3 of 2011 makes it compulsory for the developer, whether private or government, to obtain development permit from the Planning Permit and Building Control Agency prior to the commencement of any construction work or physical development on any land in the State, even as section 28, subsection (6) reechoes a note of warning that '[n]o development shall be commenced by any government or its Agencies without obtaining a permit from the Planning Permit Authority'. It goes further that it is not enough to obtain development permit, but also to embark on the approved development, since the permit is invalidated if development did not commence within two years of the granting it in accordance with the statutory provisions of section 37, subsections (1), (2), (3), and (4) of the Law (EKSG, 2011). Unfortunately, these restrictive provisions seem not to go beyond the pages of the document, as development activities without appropriate permits appear to be the order of the day, whereby buildings and structures abound in unusual places and in unwholesome manners on setbacks and public spaces in most parts of the city. This calls for a change of attitude, and the need to embrace development control regulations compliance, to restore orderliness and functionality to Nigerian built environment.

The word 'change' means to become different; to make somebody or something different; to stop having one state, position or direction, and start having another; or to replace one thing, person, service, etc. with something new or different. Change also implies the act or result of something becoming different from an original state (Oxford Advanced Learner's Dictionary, 2000), such as social, economic, political, or ideological change. The present Administration in the Federal Government of Nigeria, propelled into office by the power of the people, is committed to a change agenda to correct mistakes of the past years of mismanagement, corruption, inefficiency, and enthrone good governance. The President declares that change is a process, which has begun, and will soon give way to abundant joy as the government puts the country firmly on the path of sustainable growth and development (Aziken et al. 2016). The Vice President reiterates that change was not a mere slogan, as the country could not survive going the way it had always gone (Osinbajo, 2016). It is within this concept of change that this paper seeks an attitudinal transformation as a departure from the culture of contravention, and a resolution to comply with the enforcement of development control regulations to the letter in Nigerian cities, including Ado-Ekiti. This guarantees the right atmosphere to forestall encroachment, reclaim lost public spaces, and restore sanity into the city.

Generally, public space is a space with unhindered access for people to interact and socialize such squares, plazas, parks, garden, playgrounds, roads, waterfronts and beaches. The Urban Dictionary (2016) pictures a public space as a place created 'for everybody to enjoy their coexistence and represent their collectivity and common interest without drowning or disaggregating their diversity'. It is of great importance that public spaces are powerful instruments of social inclusion, which any equitable city or town needs to offer in substantive quantity and accessible manner (Safer Spaces, 2016). Hence, the availability of public spaces is crucial to the social life of any human settlement. As stated by UN Habitat (2015:3), 'the character of a city is defined by its streets and public spaces', while 'the quality of life for people in cities is directly related to the state of its public spaces'.

More often than not, public space is synonymous to open space. In Nigeria, most squares, parks and open spaces are public spaces established and maintained by government or local authorities. City, town and village squares were in existence before colonization. Bascom (1962) attests that the Yorubas were living in 'city-like areas' before and during the colonial period, thereby making them one of the most urbanized people in Africa. He affirmed that around 22% of the population lived in cities of more than 100,000 people, while over 50% lived in settlements of 25,000 or more. Haven likened the rate of urbanization in 1950 to that of the US based on the burgeoning of major cities such as Ibadan, Osogbo, and Ogbomoso after the demise of Old Oyo Empire, he projected that the Yoruba nation would remain the most urbanized ethnic group in Africa. Mabogunje (1962) corroborates that Yorubas lived in cities of appreciable size before the onset of colonialism, while Breese (1966) affirms that the people experienced urbanization since 1856 when Yoruba cities of over 20,000 existed, including three of over 60,000 population, and by 1911, the number of Yoruba cities had increased to eleven, with five of them having 60,000 population, and by 1952, such cities increased to nine. These settlements had public spaces of various sizes and functions, Generally as a former colony, there is British influence on the Nigerian situation in the sense that the Nigerian Urban and Regional Planning Law, Decree 88 of 1992, the Country's major physical planning and development law, was fashioned after the 1932 British Town and Country Planning Law, thereby exerting some influence of British standards in the local culture and environment.

The typology of public spaces in terms of locality, ownership structure and functional classification vary in time and space. Obateru (2005) subdivides open space into private open space, and public open space, the former being an underdeveloped portion of a plot kept open for outdoor use, while the latter is an public space owned, leased to or put in trust of the community and used by the

public for outdoor activities. In his study on open spaces in Akure, Fadamiro (2002) identifies natural and unused open spaces as mostly common, followed by recreational and commercial spaces, while religious, cultural and historical spaces are very few. This pattern is similar in neighboring Ado-Ekiti, where there is scanty provision for public spaces in form of consciously planned recreational areas and green spaces, while the few available ones, which are lacking in quality, are either poorly maintained or grossly abused (Ojo-Fajuru, 2003). Laws and regulations meant for the provision and maintenance of these public spaces seem ineffective, thereby depriving the populace of inherent benefits. These constitute the issues and challenges that this study is conceptualized to address.

The creation and maintenance of pleasurable public places is not the exclusive reserve of government. Rather, it is a public participatory development that involves the people, hence the relevance of the concept of placemaking. Placemaking is the practice of creating quality public spaces. As a vital people-oriented and community-targeted process, it elicits the support and involvement of public-spirited volunteers in the act of creating good quality public spaces. Kent (2015) posits that placemaking adopts the common sense approach that encourages and empowers the people to go beyond their own property, to conscientiously create and sustain valuable human places in their community. Placemaking is therefore a 'participatory and collaborative process', which involves interested parties, and allows the people to display their resourcefulness in the development of public spaces. As an 'open and inclusive process', placemaking promotes community's sense of belonging and the willingness to participate in its advancement. In South Africa, there are increasing number of placemaking-driven initiatives and interventions, which are intended to reclaim public open spaces, such as Johannesburg's Braamfontein Regeneration Project, and the Open Streets Cape Town movement as exemplified in Langa in depicted in Figure 1 below (Safer Spaces (2016). Similarly, the placemaking concept is indispensable to revitalize public spaces, reestablish greenery, and promote inclusion in the landscape and environment of Ado-Ekiti.

Source: Safer Spaces. Available at: http://www.saferspaces.org.za/resources [accessed: 11 March 2016].

Figure 1.Promoting the use of public spaces-Open Streets in Langa, Cape Town (c) Open Streets Cape Town

3. Objectives /Research Questions

Some salient questions rose in the course of the study, to which answers are indispensable to the accomplishment of the research tasks, such as:

i) What is the structure of land use and the existing state of public spaces in Ado-Ekiti?
ii) Of what magnitude is the incidence of encroachment on public spaces in the city?
iii) Are there any factors attributable to the level of encroachment on these public open spaces?
iv) At what levels are the people aware and comply with extant regulations on development control in the city?
v) To what extent can the illegality of public open space encroachment be established to justify reclamation and enforce compliance in Ado-Ekiti?
vi) Can green landscaping and placemaking be used to reestablish reclaimed spaces into green areas in the capital city?

In order to answer these research questions, the following objectives are stated:

i) to assess the existing state of public spaces in the urban environment
ii) to evaluate the magnitude and factors of encroachment on public spaces
iii) to examine the levels of awareness and compliance with development control regulations in the city.
iv) to justify the need to reclaim encroached public spaces to reestablish green places.

4. Key Approach to Challenges of Information Gathering and Data Collection

The dearth of planning data and non-availability of current maps of land uses in Ado-Ekiti pose serious challenges to this research. In effect, it is difficult to determine the spatial structure and the existing states of public spaces in the city. The study relied on some old maps, which were updated manually by field survey as well as aerial views obtained from high points such as communication masts, hill crests and mountain summits, prior to their digitization by the Corel Draw and Arc GIS packages. The whole exercise was strenuous, risky, costly, time consuming and, at times, frustrating especially as regards obtaining necessary permissions from communication service providers to gain access to pylons at different locations of the city. Some reprieve was derived from satellite imageries obtained via internet, which were used to tract and map the trend of development in built up areas, and expansion into the city suburbs.

Some difficulties were also encountered during the field survey and data collection exercise. Some of the people using illegal structures or occupying encroached public

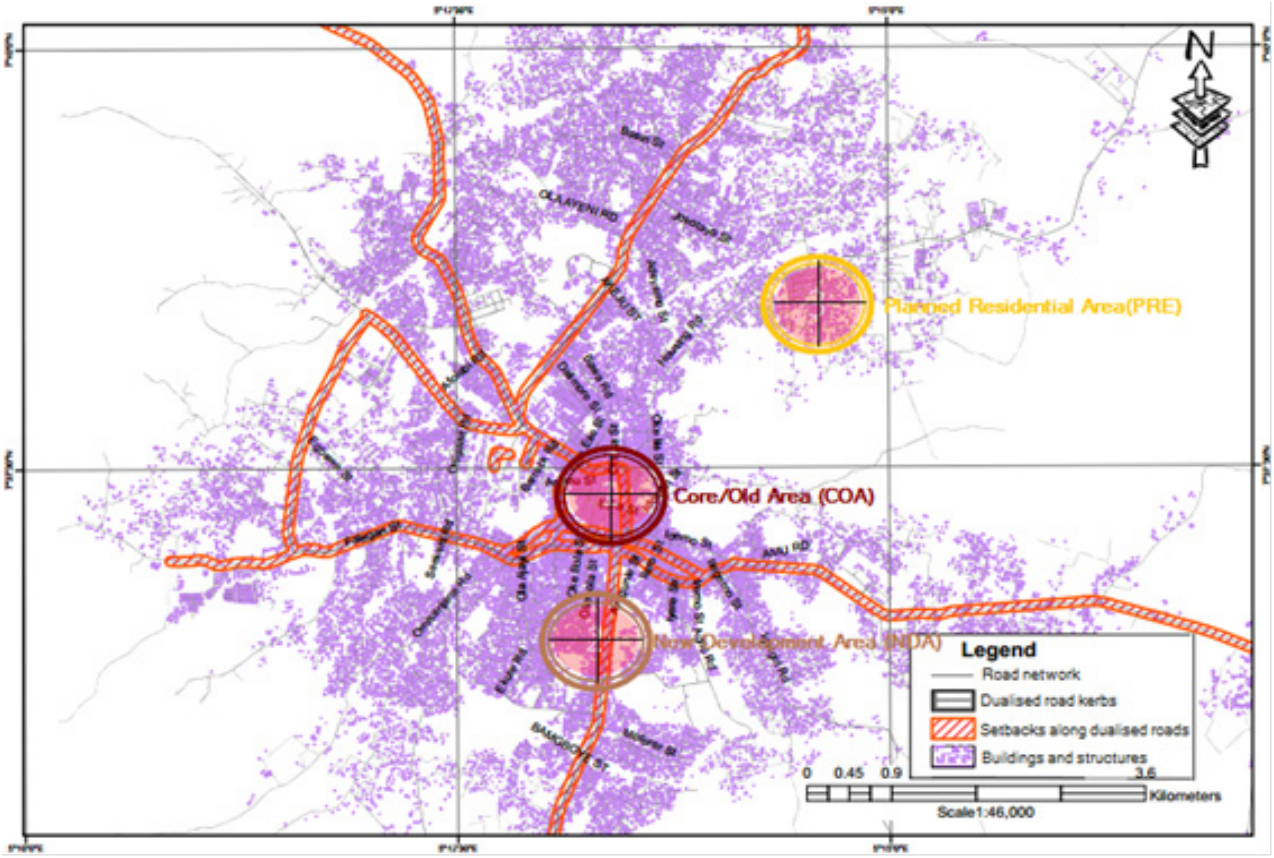
spaces were foreseen to be apathetic and antagonistic to the survey, as they are wont to assume that the exercise has the backing of government, so as to eject them from their points of operation. In order to circumvent this, the researcher sought the consent of community heads and local resident association leaders to appeal to the people and convince them before the survey commenced, that the exercise was rather academic than governmental. In order for the study to gain more moral and ethical acceptance, some enumerators and field supervisors were selected within the localities of the survey exercise. In line with basic research ethics, respondents' right to willingly participate in the exercise, or decision to withdraw anytime, were protected. Assurance was given on the confidentiality of information volunteered. Finally, the Ministry of Lands was approached for a written permission in support of the field survey exercise.

5. Approach and Methodology

The identified categories of information and data required for the research were collected from primary and secondary sources. Relevant secondary data were extracted from published and unpublished works ranging from books, journals, conference proceedings, thesis, dissertations, to e-resources, imageries and maps through the internet. Field survey generated first-hand data from the delineated study area. The multi-stage sampling technique, which proved most appropriate for the research, commenced with the stratification of the city along district boundaries. The delineation into political wards for the 2007 General Elections in Nigeria (INEC, 2007) was adapted. Hence, Ado-Ekiti LGA, a geographical unit in Ekiti Central I Federal Constituency, was subdivided into two federal constituencies. These are Ado I encompassing Ward A-Idofin, Ward B-Inisa, Ward C-Idolofin, Ward D-Ijigbo, Ward E-Ijoka, Ward F-Okeyinmi, and Ward G-Okeila; and Ado II comprising of Ward H-Ereguru, Ward I-Dallimore, Ward J-Okesa, Ward K-Irona, Ward L-Igbehin, and Ward M-Farm Settlement, all aligned with existing residential districts.

Using age, form and intensity of development as criteria in the spatial analysis of places carried out in Ado-Ekiti, neighborhoods were categorized along three contiguous morphological zones. These are old unplanned traditional core areas (COAs), new or recent neighboring colonial development areas within the last 30 to 50 years (NDAs), and planned post-colonial or contemporary residential estates (PREs) such as government reservation areas (GRAs), state housing estates (SHEs) and private housing estates (PHEs) as shown in Figure 2. It was based on these homogenous premises that some places were selected into the sampling frame.

In the unplanned core or old traditional areas, Ward A, Ward B, and Ward E from Ado I; and Ward H and Ward L in Ado II were picked respectively. Within new development areas, Ward D and Ward F were selected in Ado I, alongside Ward I and Ward K in Ado II. As for planned residential areas, made up of housing estates and G.R.As., Ward G in Ado I and Ward J in Ado II were selected. A total of 11 wards/districts were selected into the sample frame. The selection of streets was based on the three road hierarchies within each selected district: primary, secondary, and tertiary roads as shown in Table 1.



Source: Drawn by the Author based on field survey, July 2015.

Figure 2. Morphology of places as basis for neighbourhood selection into the sampling frame

Table 1. Houses selected on each selected street along morphological lines at the rate of one (1) in every four (4) houses (25%), provide the bases for the final selection of respondents in the delineated study area in Ado-Ekiti.

District	Major Road	Total No of House	25% Selected	Minor Road	Total No of Houses	25% Selected	Access road	Total No of Houses	25% Selected	**Total Selected per District**
Idofin	Mathew Street	252	60	Idemo Street	143	36	Idofin Street	114	30	**126**
Inisa	Odo Ado Street	372	90	Inisa Street	222	54	Iyere Street	168	42	**186**
Ijoka	Orereowu Street	702	174	Ajibade Lane	588	150	Orereowu	258	66	**390**
Ereguru	Ogbon Oba	606	150	Ereguru Street	654	162	Ogbon Ado	162	60	**372**
Igbehin	Igbehin Street	750	186	Igbehin	408	102	Atikankan	294	72	**360**
Ijigbo	Ajilosun Street	1014	252	Okebola Street	486	120	Eribi Street	270	66	**438**
Okeyinmi	Okeyinmi Street	636	162	Okutagbokutaleri Street	300	72	OkeIla/AnuOdo/ Okeyinmi Street	234	60	**294**
Dallimore	Dallimore Street	624	156	Kajola Street	510	126	Oremeta	336	84	**366**
Irona	Irona/Surulere	1236	312	Ola Ajayi/Ekute/ Waterworks Road	1086	270	Irona/AtundaOlu/ Oniyo Road	522	132	**714**
Oke-Ila (S.H.E.)	State Road	474	120	8th Avenue	288	72	7th Avenue	258	66	**258**
Okesa (G.R.A.)	Secretariat Road	546	138	DejiAdegbite Street	240	60	Onigari Street	222	54	**252**
Total	**11**	**7212**	**1800**	**11**	**4932**	**1224**	**11**	**2922**	**732**	**3756**

Source: Author's compilation, June, 2015.

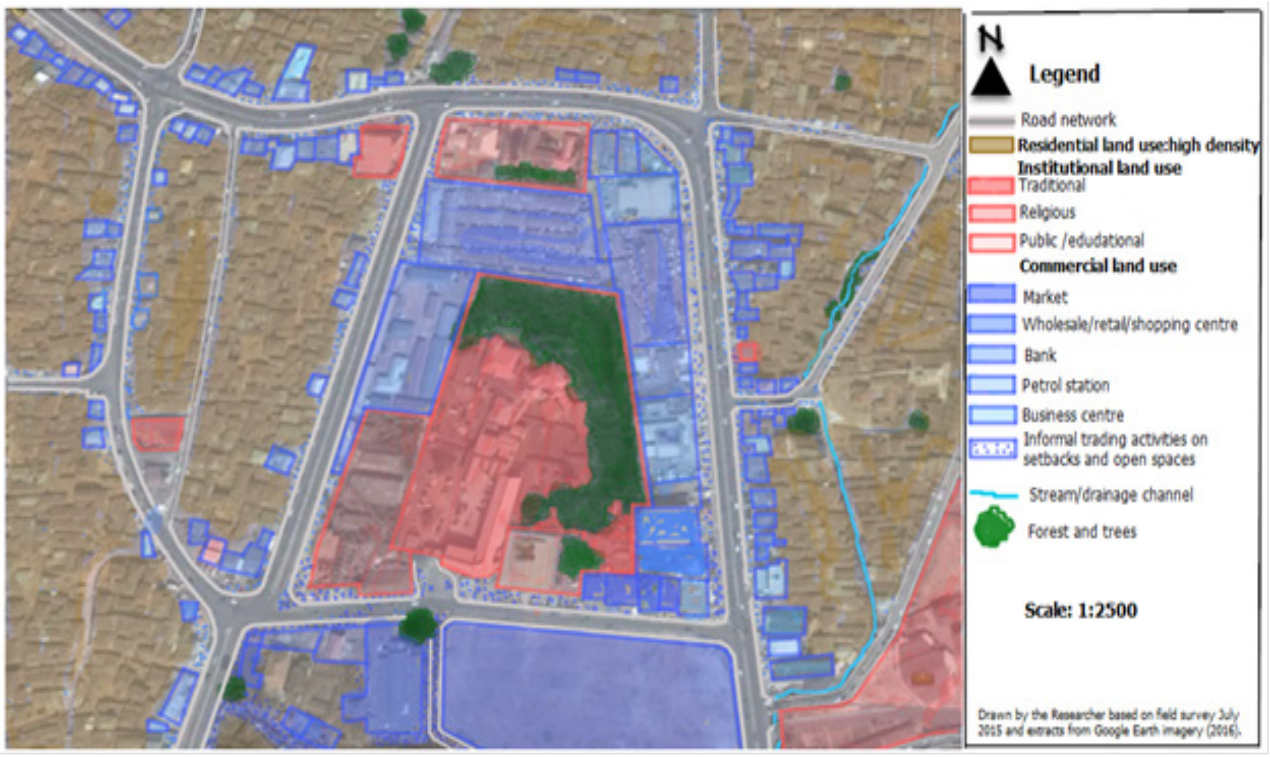
House count conducted at street level paved way for the selection of twenty-five percent of houses in each street, boiling down to one in every four houses, having made a random selection of the first house. Out of 15,066 houses enumerated, 3,756 houses or 24.93%, which approximates to 25%, were selected. Assuming that the socio-economic indicators of households in the selected districts are similar (Olanrewaju, unpub.), one person, preferably the household head, was randomly picked in each of the selected houses yielded the 3,756 respondents selected for the study. Socio-economic and environmental survey of selected districts was conducted, using research tools such as questionnaire, key-informant interviews, observations, and physical linear measurements. The baseline data generated was used to determine the spatial structure of the study area, the availability, and the extent of encroachment on public open spaces in the capital city.

6. Research Analysis & Findings / Results

Only 3,708 questionnaires were collected out of 3,756 administered. These were subjected to comprehensive sorting, following which only 3,324 questionnaires were accepted for SPSS collation and analysis, indicating a response rate of 88.50%.

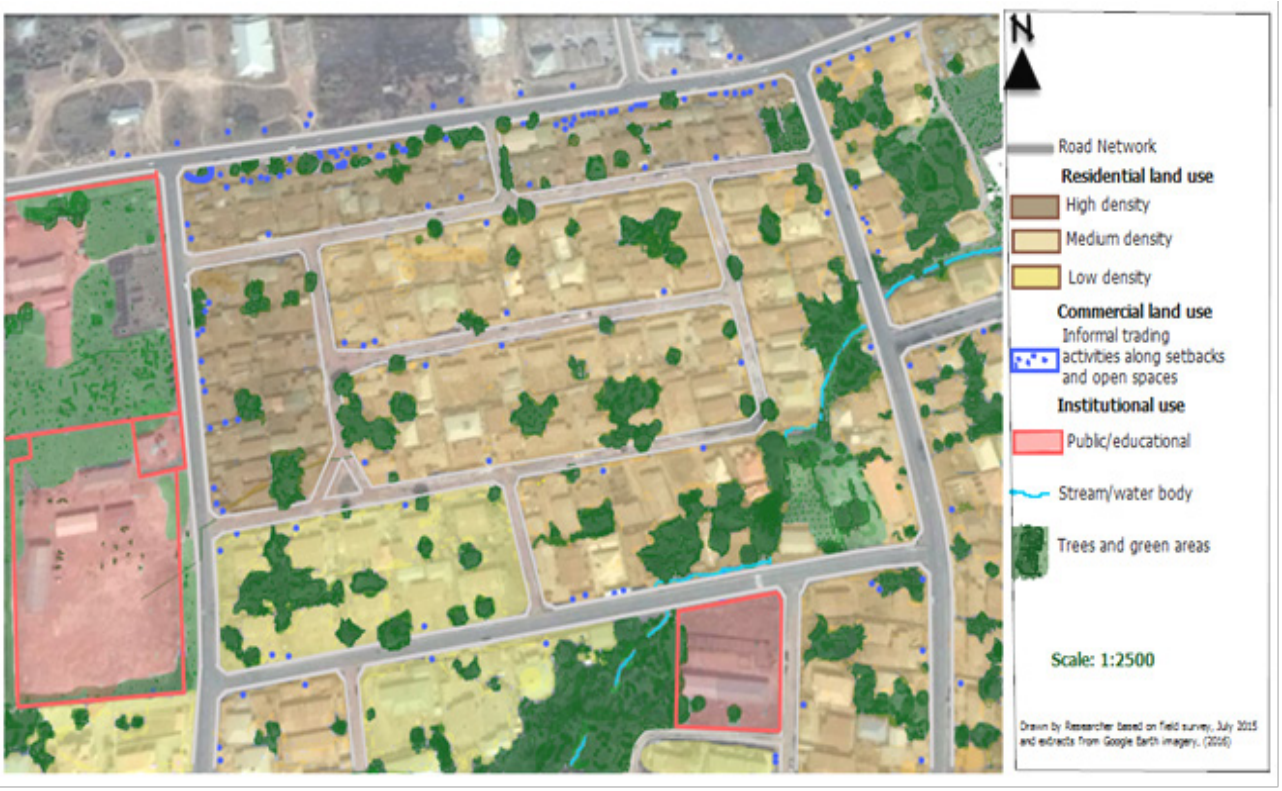
6.1. The Existing State of Public Spaces in the Urban Environment

The study reveals the dominance of residential land use in the spatial structure of Ado-Ekiti, wherein three distinctive morphological zones were identified. The sheer planlessness of the core areas and new development areas contrasts sharply with the planned residential estates in the peri-urban fringes of the city as shown in Figures 3 and 4.



Source: Drawn by Author based on field survey July 2015 and extracts from Google Earth imagery (2016).

Figure 3. The morphology of places in the core/old areas (COAs) in Ado-Ekiti



Source: Drawn by Author based on field survey July 2015 and extracts from Google Earth imagery (2016).

Figure 4. The morphology of places in the planned residential areas (PREs) in the city.

Beyond these, the city expands uncontrollably into the surrounding region with attendant vegetal destruction as typified by amorphous development along Ireje River basin within a period of ten year, captured by satellite imageries in Figures 5 and 6. Findings show that there is no conscious or commensurate replacement, which is manifested in the gross inadequacy or total lack of open green spaces in the city. This corroborates a recent study (Ojo-Fajuru & Adebayo 2016), which establishes that built-up areas and outlying regions of Ado-Ekiti are characterized by absolute vegetal removal, encroachment on setbacks and open spaces, and gross inadequacy or total lack of green spaces. In effect, land uses in the city setting are mostly bare and choked up, with few or no greenery.

Research findings expose the quantitative deficiency of recreational land use in the study area. It is quite revealing that this type of land use is virtually non-existent within the COAs as shown in Table 2 below. It is revealed that recreational land use, in the realm of public open space, is scanty, constituting a paltry 1.98% in the spatial structure of the city. Majority 61.27% respondents also affirm the gross deficiency of organized open spaces, giving credence Ojo-Fajuru and Adebayo (2016) finding the existing city spatial structure exhibiting unplanned development insufficient public open spaces and green infrastructure, which reduce livability and attraction as a great place in Ado-Ekiti. Findings also reveal only 9.94% of houses meet the legal requirement of not exceeding 40% plot coverage, while the vast majority 90.06% falls short of the requirement, indicating abysmally low compliance rate of 11.04%, and implying an urban landscape devoid of open spaces around buildings as obvious in closely built areas of the core and new development zones. The research exposes houses with less than 4.5 metres (14.76 feet) minimum front setbacks, and not up to 3metres(9.84 feet) left side, right side, and rear standard air spaces were about two-third of the sampled buildings, occupying more than two-third of core areas, nearly half in new development areas, and about one-quarter in planned estates.

Source: Google Maps, 2016.

Figure 5. Satellite imagery of Ado–Ekiti showing green areas along Ireje River basin in 2005

Source: Google Maps, 2016.

Figure 6. Satellite imagery of Ado–Ekiti revealing the subtraction of open green areas for amorphously expanding residential districts with scanty open spaces along Ireje River basin in 2015

Table 2. Recreational land use is scanty in the spatial structure of morphological zones of the city.

Morphological Zone	Total No. of Respondents	No. of Responses for recreational land use	% within Zone	% Overall
Core/old areas (COAs)	1290	-	-	-
New development areas (NDAs)	1560	30	1.92	0.90
Planned residential estates (PREs)	474	36	7.60	1.08
Total	3324	66		1.98

Source: Field survey, July 2015.

Contrariwise, buildings having minimum front setbacks of 4.50 metres (14.76 feet) or more, and left side, right side, and rear air spaces measuring 3 metres (9.84 feet) and above, ranged between one-third and a quarter in the study area, but more available in planned estates, averagely occurring in the new development areas, and sparsely punctuating the core/old areas. This indicates choky massing of building, and drastic reduction or absolute lack of open space for landscaping, which epitomizes the dearth of greenery the inner city. The research establishes that public open spaces, which should have been forests and greens, valuable for air purification, surface drainage, and recreation, are quantitatively inadequate, and qualitatively deficient, with attendant implications on scenic beauty, environmental quality, and lost employment creation and income generation in tourism in Ado-Ekiti.

6.2. The Magnitude and Factors of Encroachment on Public Spaces

The study establishes 55.21% high of encroach on public spaces such as squares, setbacks and open spaces, developed into makeshift or permanent structures mostly for commercial purposes without permission (see Figure 3). Findings show uncontrolled occupation of every available space along major roads including sidewalks, and even roadways, where informal commercial activities recorded 59.44% and 61.02% in the core and new development areas respectively, as depicted in Figure 7.

Table 3. Nature or type of encroachment on setbacks and open spaces in Ado Ekiti

Existing nature or type of encroachment	Residential use	% within zone	Trading activities	% within zone	Work-shop/light industry	% within zone	Religious use	% within zone	Used as refuse heap	% within zone	Other uses	% within zone	Total	% within zone
COAs	91	8.46	639	59.44	79	7.35	114	10.61	55	5.12	97	9.02	1075	41.08
NDAs	97	8.69	681	61.02	155	13.89	97	8.69	43	3.85	43	3.85	1116	42.64
PREs	209	49.06	125	29.34	13	3.05	13	3.05	36	8.45	30	7.04	426	16.28
TOTAL	397	15.17	1445	55.21	247	9.44	224	8.56	134	5.12	170	6.50	2617	100.00

Source: Field Survey, July 2015

The PREs exhibit a low rate of 29.34%. Similar trend of encroachment was revealed along minor and access roads, which are clogged with illegal commercial uses. Furthermore, 15.17% of encroached public open spaces are used for residential purposes; informal, unpermitted workshops, light industries and services occupy 9.44%; religious use thrive on 8.56%; 5.12% is used as refuse heaps, while other sundry uses cover 6.5% in the city, as shown in Table 3.

The study establishes that 92.24% encroachment, yielding myriad of illegal development on public spaces, negates every legal standard, reduces circulation spaces, undermines greenery, and endangers lives and properties. Findings reveal major causal factors for incessant encroachment as ignorance and carefree attitude to good quality environment (34.65%), laxity of government organs on development matters (31.77%), developers' desire for economic benefit (15.19%), increasing human activities requiring space (13.16%), and the nefarious activities of land speculators poaching the city (4.48%).

6.3. Levels of Awareness and Compliance with Development Control Regulations in the City

Source: Field survey, July 2015.

Figure 7. With illegal structures attached to houses on setback spaces; water (for sale) tanks across the drainage channel; cooking, frying and trading taking place on the road surface, it is business as usual backed by high-handed audacity and impunity at Kajola Street in the new development area of Ado-Ekiti.

The research reveals high level awareness of physical planning laws, regulations and codes regarding the obtainment of planning permits prior any development, provision and maintenance of public spaces and greens. The study finds only 47.86% of houses examined had planning permission from the approving authority, 21.26% never had development permits, while 30.85% claimed ignorant of acquiring approved building plans, cumulating to 52.11% for houses without approved plans. This indicates that more than half of houses in the city were essentially constructed without approved plans. Findings expose a disconnection between 72.00% majority claiming awareness of physical planning regulations, and the low level of compliance to the dictates of the laws. Conversely, 17.04% are not aware of any planning regulations, while 10.96% were apathetic. Findings establish that those who are aware of the laws deliberately flaunt them along with those that are not aware due to the laxity of the control agency. It proves that people willfully and defiantly engage in encroachment with impunity and cheer audacity, taking advantage of the weakness of the Control Agency (see Figure 7).

The research establishes high levels of contravention, encroachment and non-compliance, confirming that the statutory provisions of existing laws and regulations are of little effect in the control of development on public open spaces in the city.

6.4. The Need to Reclaim Encroached Public Spaces and Reestablish Green Places

The research establishes cases of contraventions and encroachment resulting to the relatively low proportion of public open spaces and greenery in the spatial structure of the city. It reveals indiscriminate vegetal removal and usurpations of public spaces, contrary to statutory provisions. Findings establish over 70% awareness of the dictates of law, which are blatantly contravened with impunity to meet challenges of daily survival, thereby resulting to waves of illegal structures clogging public spaces in the urban matrix. The study exposes the ineffectiveness of government apparatus to control development, which perpetrates encroachment and amorphous expansion. The study reveals divided opinion on the effort of government at savaging encroached setbacks and open spaces, which 20.18% viewed as poor, while 53.71% majority assessed as fair, just as good rating was only 19.25%. It is indicated that the development control authority is not performing well in its effort to reclaim the lost spaces, even as it is helpless in curtailing encroachment. The implication is that government cannot do it alone without the support of the people.

7. Research Contribution

The research generates fresh data on the existing state of public spaces in the spatial structure, wherein three distinctive morphological zones, dominated by residential land use, were identified in Ado-Ekiti. The study documents evidence that the city expands uncontrollably into the surrounding region with attendant vegetal destruction, which is manifested in the gross inadequacy or total lack of open green spaces. Vital information on the acute shortage of recreational land use in the study area is given. The revelation is original that, less than 10% of houses did not exceed statutory 40% plot coverage, while over 90% contravened. Data series generated, exposing the general inadequacy of setbacks and air spaces around

buildings, and resulting to quantitative and qualitative deficiency of public open spaces, are novel. The established high magnitude of encroachment on public spaces, mostly for commercial purposes, and factors responsible, emanate from the study. The research throws up unique information on the high level awareness of physical planning laws, regulations and codes on development control and public space provision, which does not correlate with established high levels of non-compliance manifested in highhanded contravention and public space encroachment. The exposure of the ineffectiveness of extant planning laws and regulations, warranting indiscriminate vegetal removal, and evasion of public spaces, with attendant low proportion of open spaces and greenery in the spatial structure of the city, are new findings from the study. Also derived from the research are the incapability of the development control authority to curb contravention and encroachment on public spaces; and the low rating on efforts to reclaim the lost spaces. Equally innovative is the establishment of the need for concerted effort to reclaim encroached public spaces and reestablish green places in Ado-Ekiti. The proposed Strategic Urban Greening Intervention Model for Socio-Economic and Environmental Sustainability in Ado-Ekiti Green City can be replicated, not only in other cities in Nigeria, but also in sub-Sahara Africa.

8. Discussion & Concluding Remarks

The need for a paradigm shift, to bring about strict compliance with development control regulations, and reestablish public spaces usurped in Ado-Ekiti, is central to this research. This is geared towards transforming these spaces to green places that accommodate socio-economic activities, and promote the ideals of livable, inclusive and sustainable city. With the people wholeheartedly supporting effective reversal of the culture of contravention and encroachment, being the established root cause of disorderliness and environmental degradation; and embracing the retrofitting of lost spaces, the ugly state of the city will be replaced with people-friendly environment that guarantees Ado-Ekiti as a future great city. Workable recommendations and implementable proposals are indispensible to attain this noble course.

8.1. Attitudinal Change and Civic Reorientation

Firstly, there must be attitudinal change involving all facets of Nigerian life in order to attain any meaningful achievement. Nigerians must key into the change mantra of the Federal Government to turn around the scourges of abnormalities, impunity and corruption that have continuously clogged the wheel of national development. Since change is the only permanent thing, the people must be ready to change from old ways of doing things, toe the line of discipline, patriotism, honesty, transparency, due process and orderliness; and break the jinx of defiance, impunity, fraud, underdevelopment, poverty, squalor and environmental degradation stalling significant national progress. The future of Nigeria, and those of generations yet unborn, rest in the hands of the present generation of Nigerians.

8.2. Compliance with the Rule of Law

With the people's state of mind prepared to accept, embrace and condone change, the state government should review extant laws periodically, enact new ones when necessary, and implement them to the letter to curb impunity, audacity and lawlessness in Ekiti State. The Government should cultivate the will power and take advantage of the current change agenda of the Federal Government and enforce development control regulations in the strict sense to instill effectiveness, consistency, stability and sustainability. The success story of the Fashola Administration that tamed Lagos Megacity with greening started with the implementation of existing laws of the State to the last iota, rather than enacting new ones. There were hues, cries, and even name-calling by dissenting voices, but the determination and consistency of government, headed by a Senior Advocate of Nigeria (SAN), brought about the wind of greenly change in the city environment as dividends of democracy.

Nigerians are law abiding, conscious of the law, become more courteous when the law is strictly enforced, and are wont to comply once they know that culprits will be arrested, prosecuted and punished. The rule of law should hold at all times and everywhere, no matter how highly placed the offender could be. It will be recalled that in the first coming of General M. Buhari as military Head of State in 1984, the War Against Indiscipline (WAI) initiative was lunched to stamp out corruption that bedeviled the country. The campaign was yielding results, and the people have started adjusting to honesty, orderliness and cleanliness. This euphoria of change for a better Nigeria was short-lived when the Babangida Administration stalled the process in 1985, jettisoned the programme, and commenced business as usual. Thirty years after, and having regained the helm of affairs as a democratically elected civilian President, the war that the Buhari Administration is waging against corruption and indiscipline, since inception in May 2015, has started yielding results. Ekiti State Government should emulate and replicate this feat to curb illegal development and public space encroachment, and ensure development control regulations compliance as paradigm change to revamp the poor state of the capital city environment.

8.3. Governance as True Continuum for Capacity Building

Making governance a continuum to boost capacity

building for the development control department is germane to the success of this city reinvention programme. The developmental policy somersault should be prevented, whereby successive administrations in State abandon good policies initiated by predecessors on the ground of political differences, or even personality clashes. This unprogressive saga is currently playing out in the State whereby the ruling Fayose Administration has already abandoned the flourishing greening initiatives of the immediate past Fayemi Administration, which should have been better retained, maintained and sustained to the betterment of the state capital, and benefit of the people. All need be done is capacity strengthening for the development control agency in the areas of manpower and monitoring equipment like vehicles, cameras, internet facilities and relevant gadgets for efficiency, wider coverage and improved performance.

8.4. Adopt the Ado-Ekiti Comprehensive Greening and Spatial Regeneration Intervention Master Plan as a Model for African Cities

As recently proposed elsewhere (Ojo-Fajuru & Adebayo, 2014; Ojo-Fajuru& Adebayo 2016), the proposed Ado-Ekiti Comprehensive Greening and Spatial Regeneration Intervention Master Plan (hereafter referred to as 'Ado-Ekiti Green City Master plan'),made pursuant to the Strategic Urban Greening Intervention Model for Socio-Economic and Environmental Sustainability in Ado-Ekiti Green City, and as a component of the Master Plan of Ado-Ekiti, should be subjected to public critique before adoption and conscientious implementation. Appropriate enactment should be adopted within the framework of the Ado-Ekiti Green City Master plan to chart the course of all organs of implementation, and as well legalize and support the breaking up of bare and hard surfaces for replacement with plants and flowers to reintroduce nature and biodiversity into hitherto exposed areas of the city. All open spaces naturally or incidentally occurring, including setbacks to roadways, utilities and water bodies, and those reclaimed from illegal development, as well as slopes, should be converted into massive urban forest and green areas. These should be accomplished by embarking on massive tree planting and grassing of these public spaces and maintenance of naturally occurring patches along various categories of roads to create greenways, parkways, promenades and boulevards. These will be integrated with vegetated, re-established and newly created gardens, squares and parks within the CBD and residential districts to form a network of interconnecting greenbelts, which are appropriately furnished to create great places for citizens' recreation. Selected socio-economic activities should be incorporated and controlled in designated places to accommodate displaced roadside and itinerant traders and thereby promote inclusiveness, services and improved city economy.

It is believed that with change-oriented public support and participation in development control regulations compliance, coupled with government's proactive approach to development matters, the unwholesome cityscape will be savaged, when reclaimed spaces are reestablished and maintained as dynamic green places, where organised recreational and commercial activities flourish to reinvent Ado-Ekiti as a future great capital city.

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REFERENCES

[1] Adebayo, Jegede & Ogundele 2015, 'Environmental Laws in Nigeria: Negligence and Compliance on Road

Transportation Land Use Planning Pattern in the South-South Geo-political Zone', *Donnish Journal of Law and Conflict Resolution*, 1(3) 18-28, available at: http://www.donnishjournals.org/djlcr/pdf/2015/october/Adebayo-et-al.pdf [accessed: 28 April 2016].

[2] Alao, T 2016, 'Professionals urge compliance to Lekki master plan' *The Guardian* 18 January, p. 58 available athttp://guardian.ng/property/professionals-urge-compliance-to-lekki-master [accessed: 25 April 2016].

[3] Aluko, O 2011, 'Development Control in Lagos State: an Assessment of Public Compliance to Space Standards for Urban Development', *African Research Review: International Multidisciplinary Journal*, 5 (5), 22, 169-184 available at: http://dx.doi.org/10.4314/afrrev.v5i5.14 [accessed: 28 April 2016].

[4] Aziken, E, Akinrefon, D, Kumolu, C & Oke, G 2016, 'I feel your pains Buhari tells Nigerians at the Vanguard Awards', *Vanguard News,* 9 April, p. viewed 17 April 2016, http://www.vanguardngr.com/2016/04/feel-pains-buhari-tells-nigerians-vanguard-awards/

[5] Bascom, W. 1962, 'Some Aspects of Yoruba Urbanism'. *American Anthropologist* 64 (4): 699–709.

[6] Blier, SP 2012, 'Art in ancient Ife, Birthplace of the Yoruba', *African Arts. 45: 70–85.* [Online] Available: http://scholar.harvard.edu/files/blier/files/blier.pdf[Accessed 30 November, 2016].

[7] Breese, G 1966, *Urbanization in newly developing countries*, Modernization of Traditional Societies Series, Englewood Cliff, New Jersey, Prentice-Hall, Inc.

[8] Dmochowski, Z. 1990, *An Introduction to Nigerian Traditional Architecture,* Volume Two: South-West and Central Nigeria, Ethnographical/ The National Commission for Museums and Monuments

[9] Enisan, O & Ogundiran, A 2014, 'Implications of Urban and Regional Planning Laws on Urban Renewal Projects in Akure, Nigeria', *Journal of Environment and Earth Science*, 4 (22) 46-53 available at: www.iiste.org/Journals/index.php/JEES/article/viewFile/18260/18944 [accessed: 28 April 2016].

[10] Fadamiro, JA 2002, 'Open Space Concept and the Importance for Effective Urban Environment: A Case Study of Akure, Nigeria', *Journal of Environmental Technology,* 1(1&2), 79-90.

[11] Falade, J 1985, Nigeria's Open Spaces: An Inquiry into their Evolution, Planning and Landscape Qualities, Ph.D Thesis, University of Edinburgh.

[12] Federal Government of Nigeria (FGN) 1992, *Nigerian Urban and Regional Planning Law, Decree No. 88*, Federal Government Press, Lagos.

[13] Gianoluca C 2016, *The Law of Public Spaces* Portland: Sustasis Foundation, available: http://www.sustasis.net/Crispi.docx [Accessed 11 March 2016].

[14] Gray, J 2011, "*Public Nuisance Law: a Historical Perspective"* available at: www.wikipedia.org [Accessed May 2011].

[15] Ibrahim, RB & Toyobo, AE 2014, 'Appraisal of Development Control Activities in Ogbomoso South Local Government, Oyo State, Nigeria', *Asian Journal of Science and Technology,* 5(6), 313-319, available at: http://www.academicjournals.org/ajpsir [accessed: 28 April 2016].

[16] John Paul II, 1979 *Encyclical Letter: Redemptor Hominis*, 15, AAS 71, 287.

[17] Kent, E. 2015, Placemaking as a New Environmentalism: Reinvigorating the Environmental Movement in the 21st Century, New York: Project for Public Spaces, available at: www.pps.org/reference/placemaking-as-a-new-environmentalism/ [accessed: 18 March 2016].

[18] LASG 1986, *Town and Country Planning (Building Plan), L.S.L.N. No 15*, Government Press, Lagos.

[19] Law Dictionary 2016, 'Compliance'. Available: http://www.merriam-webster.co/dictionary/compliance [Accessed 28 April 2016].

[20] Mabogunje, AL 1962, *Yoruba Towns*, Ibadan, Ibadan University Press.

[21] Nigerian Institute of Town Planners (NITP) 2014, *State of Planning in Nigeria*, Abuja: NITP, available: nitpng.com/pdf%20docs/soplanning.pdf [Accessed 26 April 2016].

[22] Obateru, OI 2005, *Basic Elements of Physical Planning,* Penthouse Publications Nig. (Visionary Publishers) Ibadan.

[23] Oduwaye, L 2014, 'Imperatives of the Greening Culture in Contemporary Nigerian Cities*'*, in *Building Clean Cities in Nigeria,* edited by B. Wahab, N. Atebije, & I. Yunusa. , Abuja: Nigerian. Institute of Town Planners (NITP) & Town Planners Registration Council of Nigeria (TOPREC), 181-226.

[24] Ogundele, FO, Ayo, O, Odewumi, SG, & Aigbe, GO 2011, Challenges and prospects of physical development control: A case study of Festac Town, Lagos, Nigeria, *African Journal of Political Science and International Relations,* 5(4), 174-178, available at http://www.academicjournals.org/ajpsir [accessed: 28 April 2016].

[25] Ojo, AG 1966, *Yoruba culture: A geographical analysis*, Ile-Ife and London: University of Ife and University of London Press.

[26] Ojo-Fajuru, JO 2003, Planning for Recreational Open Spaces in Ado-Ekiti, Nigeria, PGD Dissertation, Federal University of Technology, Akure.

[27] Ojo-Fajuru, JO 2012, 'Green Landscaping Techniques: the Leeway from Pollution and Climate Change to Urban Landscape Sustainability in Lagos Mega-city**',** *Global Climate Change, Environmental Pollution and Food Security: Implications for Africa: proceedings on 2nd Biennial International Conference,* 18th-20th April, 2012, Environmental Research Group, Lagos.

[28] Ojo-Fajuru, JO & Adebayo, AA 2014, Greening and Furnishing Setbacks, Open Spaces and Parks towards Making Great Places to Promote Livability and Inclusiveness in Regional Capital Cities: the Case of Ado-Ekiti and Akure, Nigeria. A Paper presented at the Planning Africa Conference 2014, International Conference on *Making Great Places,* organised by South Africa

Planning Institute (SAPI) held at the International Conference Center, Durban, South Africa between 19th and 22nd October, 2014.

[29] Ojo-Fajuru, JO & Adebayo, AA 2016, 'Recovering Lost Socio-cultural Spaces to Reestablish Sustainable Green Places and Reinvent Ado-Ekiti, Nigeria as a Great City of Tomorrow', in *7th Planning Africa Conference 2016-Making Sense of the Future: Disruption and Reinvention,* South African Planning Institute, Johannesburg.

[30] Olanrewaju, DO 1990, Spatial Distribution of Urban deprivation in Akure, Ondo State, Nigeria. Ph.D Thesis, University of Sheffield, pp 40-43.

[31] Olaseni, AM & Ojo-Fajuru, JO 2015, Course Brief, Lecture notes distributed on URP 426: Professional Practice, Yaba College of Technology, Yaba, Lagos, on 09 December 2015.

[32] Onokerhoraye, AG 1976, *Urban Environmental Problems and Planning Strategies in Tropical Africa*, Ibadan, Nigerian Institute of Social and Economic Research.

[33] Onokerhoraye, AG 1995, *Urbanisation and Environment in Nigeria: Implications for Sustainable Development*, the Benin Social Science series for Africa, Benin City, University of Benin.

[34] Osinbajo, Y 2016, *VP says change is irreversible,* Abuja: NAN, Pulse News Agency Local, New Agency of Nigeria, available at:http://pulse.ng/local/osinbajo-vp-says-change-is-irreversible-id4953702.html [accessed: 29 April 2016].

[35] Oxford Advanced Learner's Dictionary, 6th Edition 2000, Oxford: Oxford University Press.

[36] Safer Spaces 2016, *Public spaces: More than 'just space*, South Africa: SS, available at: http://www.saferspaces.org.za/resources [accessed: 11 March 2016].

[37] UN Habitat 2015, *Urban October 2015 Background Paper: Public Space for All-Designed to Live Together,* Nairobi: UN Habitat, available at: http://www.unhabitat.org/public-spaces-for-all-2/ [accessed: 18 March 2016].

[38] Urban Dictionary, 2016, Public space Available: http://www.urbandictionary.com/define.php?term=public+space&defid=983396 [Accessed 28 April 2016].

[39] Wikipedia, 2016a, Regulatory Compliance, Available:https://en.wikipedia.org/w/index.php?title=Regulatory_compliance&oldid=716749428 [Accessed 28 April 2016].

[40] Wikipedia, 2016b, Compliance Available: https://en.wikipedia.org/w/index.php?title=Compliance&oldid=665480149 [Accessed 28 April 2016].

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Urban Strategies for a Renewal of Algerian Cities: Constantine of Tomorrow

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Abstract The town is not 'fixed', it is constantly developing, transforming, extending, renewing... These developments are made according to inhabitants needs, the evolution of lifestyles, opportunities or territory projects, policies, wills ... etc.; But also according to the capacities for the evolution of urban fabrics and social acceptability of this evolution. Today, urban intervention takes place in a context of 're-urbanization' marked by territorial and socio-economic complexity and by uncertainty. While new fabrics become increasingly important and concern the notion of 'project' instead of that of 'plan'. In Algeria, since independence in 1962, the town plan had been promoted as a 'plan' which had worked to extend the city beyond its fringes in order to respond to ever-increasing demands for housing. After years of drastic cuts in public spending, a turning point seems to be taking place. Indeed, the last two decades have been marked by many political, economic and social modifications at the same time. Through a financial upturn, the government committed itself to a series of reforms aimed at boosting the economy, increasing housing and employment, and undertaking extensive urban restructuring work. This new socio-economic context has led, in an unprecedented way, actions and interventions on the existing urban fabrics, to prefigure Algerian city modification and bringing out new and complex problems. Thus, in parallel with an Algerian city that continues to spread, the existing city is moved by a profusion of structuring public projects but also different operations of transformations; So many actions that can be assimilated to the beginnings of urban renewal for the Algerian city. The capital of Algerian east 'Constantine', is a city that could be described as an 'incomplete metropolis', it is highly renowned for many specificities, yet it has a specific crisis in relation to its context and its Urbanization, its upgrading is imminent and adapts itself to the international economy within the framework of a sustainable development in relation with the quality of life and the future of future generations. It seems to know, as Algerian cities do, many actions and projects that are transforming. The main objective of this work is first, to examine the effectiveness and relevance of the degree of involvement and involvement of local actors, in particular the users, and finally to consider the consistency of the programs.

Keywords Urban Strategies, Urban Renewal, Mutated City, the Future Town, Constantine

1. Introduction

Urban sprawl, the dispersal of the built environment, the proliferation of motorized travel, increasing waste volume, flows, the use of energy and the development of new uses, result from the economic and social forces of the current era, and support excessive urbanization. Indeed, new dynamics now characterize the cities, the majority of countries are experiencing dysfunction and negative urban dynamics. Outcome: transformations in approaches of urban planning have been made, and the cities are experiencing transformations and mutations that correspond, sometimes, with real vectors of positive change.

It is true that for a long time, the intervention over the city consisted of a major production of buildings and infrastructures in inbuilt areas and intended for individuals with relatively homogeneous aspirations. Today the development of cities is in an already heavily built environment and is intended for individuals with very diverse aspirations. The urban intervention is therefore in the context of "re-urbanisation" marked by territorial and socio-economic complexity and uncertainty[1]. Therefore, new challenges are becoming increasingly important and the use of the term "project" instead of "plan"; because it is no longer a matter of regulation, guidance and growth control, often on the outskirts of the city, but to find initiatives to stimulate the development of central areas and slow the urban sprawl. This is more commonly called the urban renewal or reconstruction of the city on itself. This

corresponds to the definition of an option to counter the trends of sprawl and urban dysfunctions, a trend that seeks to overcome the urban crisis and to reconsider the city and its development.

2. Objectives and Methodology of Work

Algerian city lives a specific crisis context and its course of urbanization, it should more than ever be renewed, its upgrade is imminent, and it must also accommodate an agreement with the international economy and a sustainable development approach that cares about the quality of life and future of generations. In front of its high stakes, it seems to experience many actions, and projects that hold transformations. In this context, it is important to question the effectiveness and appropriateness of its actions which seems to be imported from elsewhere!

To better understand the reality of matters and determine all this, our choice fell on the city of Constantine that could probably be described as 'an incomplete metropolis' and a highly reputable 'regional capital'. This choice was almost imposed because it favors the observation of a transforming city...

The latter already plays a significant and structuring role on a regional as well as a national scale, it presents a delicate and disadvantageous situation; indicating numerous dysfunctions and a loss of its architectural, urban and identity properties, particularly in the area of ancient and heritage fabrics.

The objective of our work is to examine the transforming situation and to measure the importance of the renewal issue of the project of metropolization of this great city. In this case, the confrontation between theory and reality, as well as receptivity of residents and users representing the fundamental support of our research.

3. The Urban Project to Renew the City: Towards the City of Tomorrow!

The concept of the urban project is at the heart of urban renewal of the contemporary era, it is a formula that has mainly been used in Europe since the seventies, to counter the functionalist urban planning within a changing socio economic environment (awareness in relation to the crisis of the city, development of urban thought, and science in general). In fact, urban standardized and reproducible responses are becoming rarer and less and less effective. This requires special attention to the processes that organizes the intervention appropriately to each particular case. Therefore, urban policies evolve and the urban project acquires a place among the new forms of intervention on the city. This new situation is essentially characterized by the withdrawal and the changing role of the public sector in the definition and implementation of urban development. The withdrawal and disinvestment of the state is partly explained because of the crisis in public finances. But it also reflects an illegitimation of the State in terms of planning as much social as spatial, which reflects the development of neo-liberal policies and the crisis of the welfare state (It is precisely in this situation where Algeria ended up during the late 80s and early 90s).

The urban project gives birth to a new dimension of urban policy integrating the concepts of negotiation, consultation but also compromises between the different actors in the city. So it can become a "city project", "social project", where it really involves its beneficiaries and is not limited to a simple urban marketing operation. It is also considered as a new approach to spatial intervention that may provide a framework of a rolling action and self-regulation, open, flexible and efficient. It aspires to improve the quality of urban life and try to correct the imperfections of urban planning. It takes into account all the data characterizing an area, a town, a commune, from an economic point of view, sociological, or cultural, while considering the geography of the land, the history of existing assets and by giving priority to a prudent management and space control[2]. The urban project defines an approach that is in line to write another city on the city; renew the city that is designed in the absence of quality.

Indeed, Renewing a city is to change it widely and to demonstrate several principles, this leads to conduct a real project: policy renewal - enhancement of the economic aspects - of reconnection and social cohesion - revaluation of the cultural aspects and contextual specificities, respect for the traditions and the past while seeking to open up to the renewal for a city of tomorrow. Referring to the city of tomorrow, is also to adopt, in the context of the renewed city, a vision of sustainable development, a vision that aspires to be the new ethic of the future: a re-humanization of cities, a unique social and urban project for each city and a true "project of a city".

4. Urban Project and Metropolization of the Big Cities of Algeria

Research has shown that Algerian cities unfortunately result from the absence of a coherent and cohesive development policy. Indeed, during the post-independence years, population growth and the rural exodus forced the authorities to adopt policies of mass production of housing to try to control its crisis and to curb the phenomenon of slum. According to this view, the extensions of the Algerian peripheries were made by breaking with the old nuclei, and the incoherence was accentuated by the propagation of repetitive and monotonous urban and architectural forms. The various urban planning instruments, for their part, focused on the programming and quantification of needs and their spatial locations, in addition to their dislocation with the rapid changes in

urbanization. The Algerian city was therefore shaped in the absence of landscape and architectural quality.

However, we note that since 2005, agents of change and profound transformations are gradually implemented in the Algerian city (especially big cities). This is due primarily to favorable economic conditions (including hydrocarbon revenues), but mostly the desire to integrate the global system, which is considered a necessary step in any development.

In fact, it is in a context of agreement with the international economy and in order to "stay in the race" in globalization, that is to affirm the will to "metropolize" major Algerian cities. Indeed metropolization can be identified as a territorial development and development strategy, in order to provide the great city with the assets and the "image" necessary for its integration into competitiveness.

Today the urban landscape in these cities reflects the image of cities that are implementing major facilities, the urban project seem to be the basic element in the work of 'reconstruction' of 'cityscape'. The projects are real elements of upgrade, developed through a set of strategies for implementing standards of modernity, to hoist the Algerian cities competitiveness thresholds required in Maghreb, Euro-Mediterranean and global areas. They are an opening provider but may result in discontinuities and multiple inequalities...

However, it must be admitted that these actions remain the prerogative of public policies, and the contribution of other private actors and economic operators remain also minimal if not absent.

5. Brief Presentation of the City of Constantine

The will to deliver a presentation of the city of Constantine in a few lines is almost impossible. Indeed, what to say about this city that is doubly millenary, a defensive site surrounded by the Rhumel whose gorges make two kilometers long and one hundred feet deep[3], a picturesque landscape of the finest in the world . Its privileged position (intersection between the boundaries of the high plains by its south and mountains of the tell in the north[4]), its particular history and its original character, came together to make this city the largest commercial grain market, a craft center, a center of worship and culture, a kingdom and a regional hub for many civilizations ... and that since ancient times. Today it is the capital of eastern Algeria.

The site on which was built the city is provided with favored assets that pushed each conquering civilization to superimpose their cities on the ruins of the previous one. You cannot make a step back to summarize the history of Constantine without emphasizing the permanence of its heritage, and that it was built and rebuilt many times, it is a stratified tissue of cultures, civilizations and stories. This provides information on the background that supported this city, and helps to better understand the changes and transformations that are being prepared today.

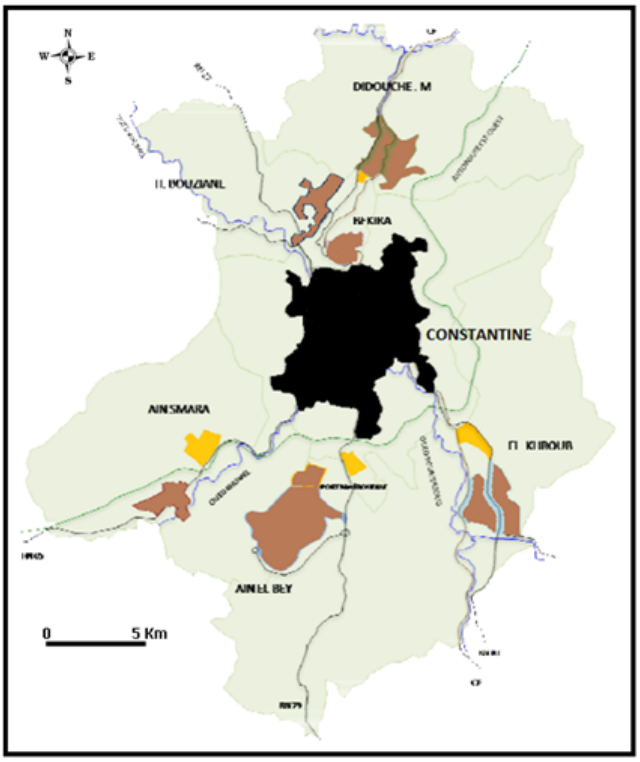

Figure 1. Metropolitan area of the Constantine city

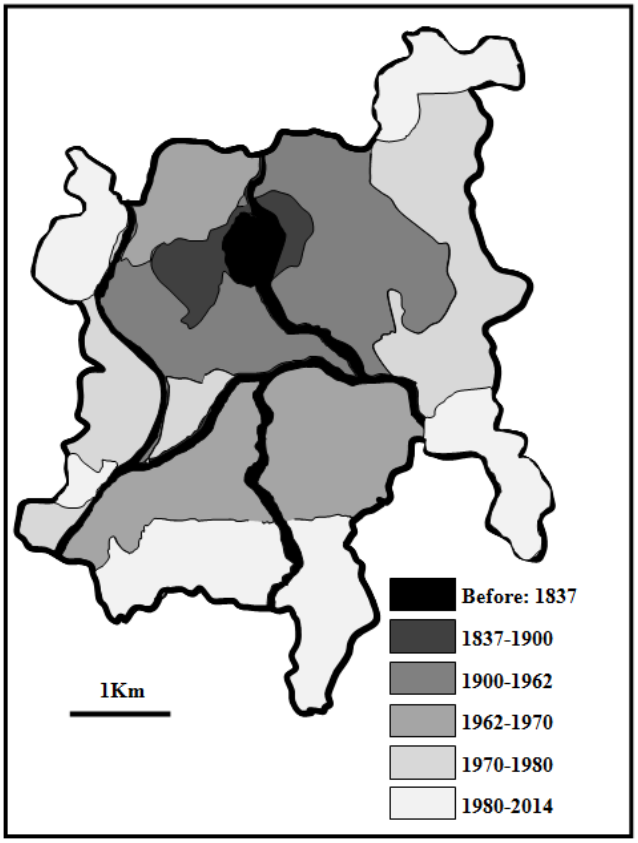

Figure 2. Evolution of the Constantine city (1837-2000)

The reconstruction of the city's diagenesis[5] should be required to understand how was Constantine of yesterday to better ... " draw 'Constantine of tomorrow.

6. Constantine in the Contemporary Era: Issues and Prospects

The city of Constantine knows, in our era of all the turmoil, like the Algerian towns, a delicate and disadvantaged situation; including: a chaotic, sprawling spread of its periphery at detriment of the quality of life, environment, loss of identity and cultural landmarks within the anonymity of housing estates and unfinished housing development, and a loss of architectural and urban property, central ancient fabrics (the old rock / (Old Town) among others) inclined to continuous degradation, malfunction, congestion, inadequate practices, neglect and devaluation of public space ... etc. Constantine is therefore formed without synergy between different urban entities. But she has known for almost a decade the application of an ambitious modernization plan (MUP) for its revitalization and outreach! (See fig. 3).

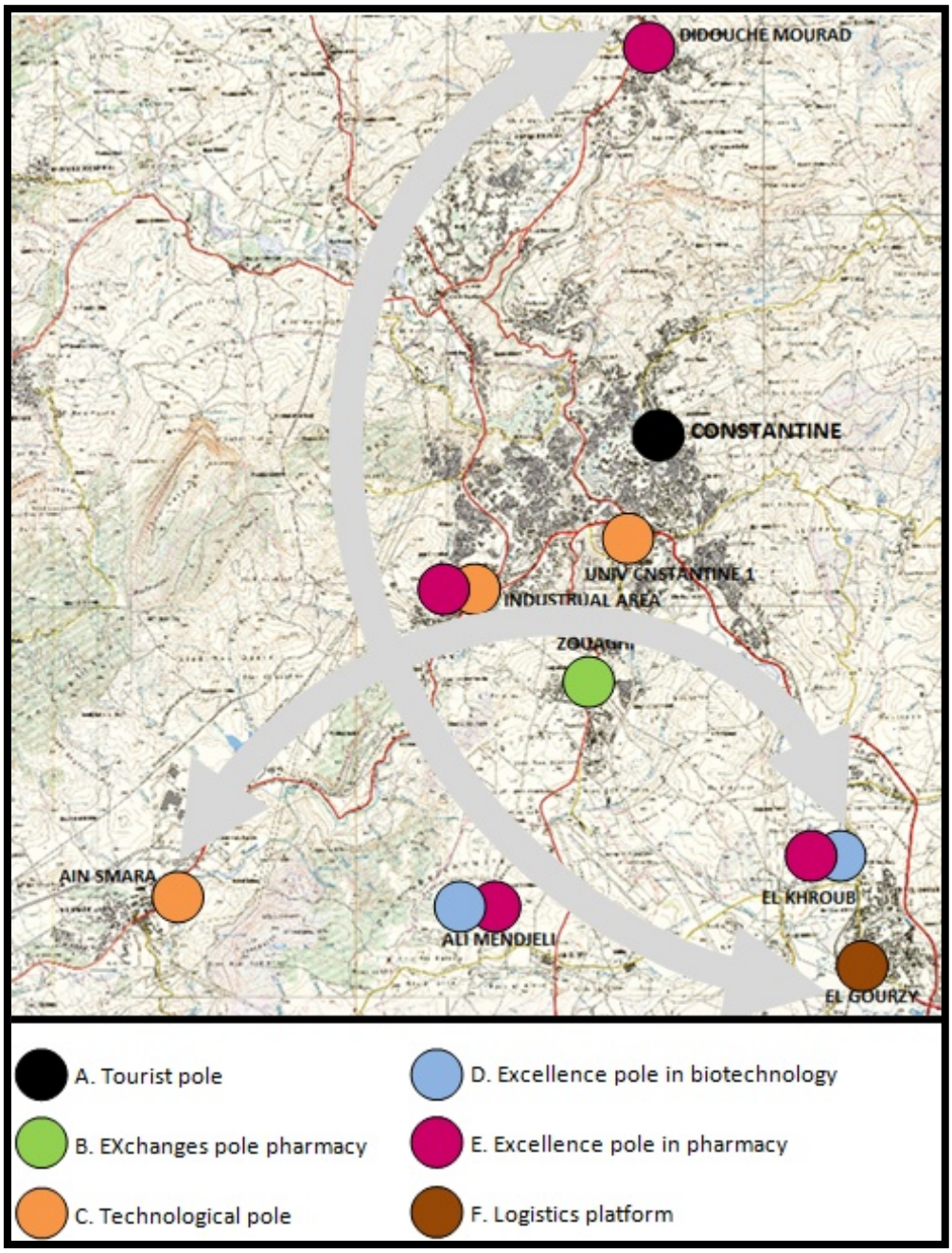

Figure 3. Major components the PMU of Constantine

Table 1. Major urban projects in Constantine

Poles of the UMP	Projects launched	Features - Progress / impacts
Tourist hub Heritage - administration (Medina, Koudiat and Bardo)	- The project to rehabilitate the street of Mellah Slimane (old town: the rock) launched under the Permanent Safeguard Plan and Enhancement of Protected Sectors. - Rehabilitation and restoration through Souika.	-The PPSMVSS of the old city of Constantine began in October 2007, the project has taken the appearance of an urban project (consultation with all stakeholders and especially the locals). Other actions are still in progress.
	- Bardo, Djnan Tchina. 02 shanty towns that have been demolished.	- the operation of demolishment allowed to recover perfectly buildable land assets which will be erected modern buildings near the old city center (work in progress).
	Launching of the construction of 03 hotels (luxury).	- Ibis and Novotel: completed The Mariott (under construction) in addition to 04 other hotel launched in satellite towns.
Transit hub and Commercial Services	- Construction of an international airport as well as the refitting of the former Hall and the construction of new airport runways.	- The construction project is completed and the goal was to increase air traffic so to provide more quality service to travelers.
	- Central Multimodal Station in Zouaghi (tramway terminus) will regroup in a few months the two existing stations in order to decongest the city.	- Acting as a catalyst and influence on urban regeneration, the proposed station will have a global impact on the dynamics and the image of Constantine. However, as it is not yet realized, research of the project impacts can only be prospective.
Networks and infrastructures for mobility	- The tramway, 9 km of line from the city center to Zouaghi, with a capacity of 160 000 passengers / day, 08 stations and 03 poles of exchange.	-The Tramway offers since its launch in July 2012, to promote the use of clean public transport respectful of the environment. - Enabling a real improvement in comfort and / or speed for users. - It has improved the quality of public transit because the tramway line is positioned on one of the axes of the highest demand over the old buses that were deleted or shortened. - The cost of transport is still relatively high and does not suit all social categories.
	- The completion of the cable car.	- The cable car has allowed thousands of users to use a convenient, fast and environmentally friendly transport mean, thanks to its two distinct sections. The first, from the street of Tatache (formerly rue Thiers) joins the university hospital with a length of 425 meters. The second, more important, joins the same UHC to the Emir Abdelkader city (formerly Faubourg Lamy) and has a length of 1,091 meters.
	-The Project of Trans-Rhumel, it is a giant viaduct which will span the Rhumel and connect both banks over a length of 1,150 m.	The work is in progress, and will have four roadways and one for the tramway, for the UN square (El Fedj) and goes up to the plateau of Mansura. A behemoth designed to connect several neighborhoods and reduce the strain on the current roads network and will allow more fluidity for traffic which cannot support the growth of the car fleet without benefiting from such important road network solutions, it will be commissioned in the course of the year 2014 and therefore its impact will remain prospective.
	The project of the Trans-Rhumel is now effective. This is a giant viaduct which will span the Rhumel and connect both banks over a length of 1,150 m.A bridge oriented to be functional, but whose appearance seems to be of prime importance.	

Indeed, the "Modernization Project of the Constantine Metropolis" (PMMC) initiated since 2007 by the President of the Republic, aimed at breaking with the previous logics of development and planning. The project has thus declined a desire to give legibility to structuring projects. It was also a question of asserting a general coherence on the territorial plane of the metropolis, and creating a real articulation between the different domains and sectors (ref SCU). It was structured around three main objectives: urban "remodeling", improvement of transport networks and attractiveness of tourism. The culmination of this vast and profound enterprise would be "the re-new of

Constantine's face". Numerous actions have been deployed within the framework of this ambitious modernization project[6], in order to regain the dynamism and regional influence of the historic metropolis, in particular by enhancing its intrinsic, patrimonial and identity potentialities and enhancing the image Of Constantine metropolis.

This modernization reflects a «political» desire on two levels: first to make a qualitative transition, by equipment acquisitions (the various initiated projects) and thus put the city and region in range with the world; Secondly to achieve a positive change in the living environment of the users and citizens. The new approach of the urban strategy aspires to be qualitative multidimensional; breaking with the punctual and sectoral actions of previous developments.

Other projects exist in the city, and concerns varied and numerous actions both for upgrading, redevelopment, urban improvement, refitting ... etc. Especially as part of the event of Constantine, the capital of Arab culture. In fact, the Arab Organization for Education, Culture and Science (ALECSO) had designated Constantine as the capital of Arab culture in 2015, the event represented a real revival for the capital of the East on every front the plans would enable it to upgrade its cultural infrastructure, both in the capital of the province and in all the other communes. Many actions have therefore been implemented, but their coordination and impact remain a matter for debate.

7. Urban Renewal Project for the City of Constantine: between Theory and Practice

All the actions taken in the city and its agglomeration reveals a profound spatial, social and economic reconfiguration that is about to take place .This announces the beginning of a new face being painted gradually for Constantine of tomorrow; as well as new human relationships (the upheaval of old) and a new urbanity!

Despite the existence of a modernization plan that could be likened to a founding charter, it must be noted that the actions do not really reflect the character. They remain individual responding to specific problems, which may produce discontinuities that will only aggravate the problem of dislocation experienced by urban spaces. The fact is that some projects were decided well before the launch of the famous modernization plan; they were built there later, which provides information on the differences in the approach and in the overall approach. Modernization was not thought integrally as envisaged in the urban coherence plan.

Another observation raised concerns territories affected by the projects, which are in large majority central and / or strategic, and a number of suburbs with a deplorable living environments, are still waiting to be upgraded, facing an emergency situation worth taking a convincing support.

The new perspective of modernization and development to meet universal standards established in Constantine is based on the urban plan as a tool for action and whose doctrine favors the elimination of spatial and social imbalances in the context of an open process , participatory and involving all stakeholders in the city. But the fact is that multiple inequalities emerge, residents meanwhile remain excluded from effective participation in various real actions. Residents and users, because of their practices are real actors influencing predominantly the realities of the city. What is needed is the dialogue and coordination of efforts in order to reorient all the dynamics (spontaneous and planned), reintegrate and lead an improvement in lives of people. Rethinking Constantine of tomorrow must past through good 'listening' to the society that invest in it. What we can demonstrate, it is the absence of a civil society capable of executing an anti-establishment in Constantine, but also throughout Algeria. The fact is not due to unawareness of the citizens, but rather it is the fact that Algerian society is struggling to organize and polarize toward common interests[7]. The people convey a dynamic and real strategy to a convergent urbanity: they have a skill to produce their city of tomorrow.

8. Conclusions

Following the state of the city, Constantine has a fragmented urban network, with public spaces that are abandoned or no longer fulfill their role as a link, roads undersized and congested, thus raises a specific and complex problem. Each urban entity was created under specific conditions, and bears characteristics that isolate more or less from the rest of its spatial, social, economic environment. The urgency for Constantine is to practice true integration of all these entities in the same urban system, to improve the image and quality of life of the city for its residents and users and mitigate the propagation of its anarchic sprawl, these are the major challenges of Constantine. It is only once these objectives will be achieved, that we can claim that this big city can have a place among the international cities.

It is true that its today's image is renewed thanks to two movements;

- Spontaneous and punctual renewal, with a commercial characteristic, sometimes illegal, essentially driven by residents and users.
- A planned renewal managed by multiple regular projects, which remain sector-based, sometimes individual ... though managed by a modernization plan.

The metropolization project initiated in Constantine constitutes an ambitious vision and a challenge for the city

to get in line with globalization. It comes to a long-term project that will bring a major development. This will be possible, in our opinion, only if the many projects launched may first allow citizens to access better life standards in a quality environment, and eventually upgrade and modernize the city through large-scale international facilities.

An urban project in the prospect of a renewal and an upgrade of the city is a multidimensional project, which should be based on several aspects of both: economic, social, environmental, deep knowledge of the built environment and its realities, it is expected to create wealth and generate endogenous dynamics that may incorporate humans, meet their expectations and make him rediscover the pleasure of experiencing the city as the user continually adapts to his space, he deserves to be integrated and especially involved in the renewal process engaged. The city project must result in concrete actions having a direct and visible impact on the city and on the city-dweller, as part of a real coherent and cohesive global strategy that will have to be structured through scales and a timeline of action. Solutions can not emerge from nothing, it is permissible to be inspired, and the most important is that the greatest consensus was gathered around a local context. The urban project in Algeria should not be regarded as a goal, a speech that we have to adopt absolutely, but it should rather be an approach to be adopted to try to restore welfare, social justice, respect of nature and of man, by actions appropriated to the conditions that arises. It is only in this way that we can consider a strategy of upgrading for Constantine.

REFERENCES

[1] CAMAGNI, R. GIEBELLI, R. *développement urbain durable*. l'aube, Paris, 1997.

[2] SEDJARI, A. *Aménagement du territoire et développement durable: quelles intermédiaires*. Ed: L'Hamattan, 1999.

[3] BIESSE-EICHELBRENNER, M. *Constantine: La conquête et le temps des pionniers*. L'Hay - des Roses, p: 208, 1985.

[4] Agence Nationale d'Aménagement du Territoire. ANAT. *Bilan diagnostic et orientation d'aménagement, Phase N°1 : Diagnostic de la wilaya*, 1994.

[5] GULLON, R. *Diagenèse urbaine? In: Le magazine international de l'architecture et de la ville*. Urbanisme, n° 308 – Renouvellement urbain, p p: 81-82, 1999.

[6] Un grand projet de modernisation urbaine d'une capitale régionale, Wilaya de Constatine, 2010.

[7] SAHRAOUI, B.T. *Peut il y avoir développement durable en Algérie*. Rapport apparu au Quotidien d'Oran, Dimanche 02 Mai 2004, p: 9, 2004.

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Rehabilitation of an Edified Building in a Seismic Zone in Algeria According to the Eurocode 8-3

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Abstract The objective of this paper is to perform a study on rehabilitation of a vital seven-story administrative building located in a low seismic area according to the old Algerian earthquake regulations (RPA88). Modifications were brought to the old code, including the seismic zoning which passed from moderate to high seismicity. The applied rehabilitation standards are based on the recommendations of the Eurocode 8-3 (EC8-3). The assessment of the vulnerability of the existing construction showed that the seismic forces at the base are lower than those required by the Algerian seismic code RPA99/V2003. As a retrofitting measure to strengthen this construction, the addition of new shears walls in both directions of the building was proposed. The dynamic study of the structure with the suggested structural intervention fulfilled all the required dynamic characteristics. For setting evidence of the performance of the proposed strengthening solution for the existing construction, a non-linear static analysis or pushover was accomplished. The obtained results using the SAP 2000 software enable us to make a comparison between the nonlinear behavior of the modified structure and the initial one. Compared to the original structure, from the point of view of the performance status, the strengthened structure showed a marked improvement in the strength and damping exceeding 80% while the overall capacity for resistance is enhanced more than three times.

Keywords Rehabilitation, Building, Eurocode 8-3, Retrofitting, Strengthening

1. Introduction

Many reinforced concrete constructions yet in service in Algeria , especially those built before the enactment of the governing seismic code in 2003[1], were originally designed to support only gravity loads lacking the needed stiffness to deal with even a moderate seismic event. According to the current earthquake standards old reinforced concrete structures were designed and built without essential seismic details deemed vital to withstand large lateral loads. These old buildings could cease their serviceability and seriously jeopardize the safety of occupants because of the influence of complex interacting phenomena such as shear deficient columns which are the most critical elements present substandard shear design to inhibit shear failure, improper splicing of longitudinal reinforcement bars (insufficient lap length, and/or improper lap location), structural system consists of weak columns and strong beams , and finally unsafe design and detailing within the joint region beam-column connection nodes with less shear stress capacity [1].

Usually earthquakes induce damaging lateral forces but may become more deteriorating because of ignorance or lack of effective and integrated rehabilitation. Indeed, precipitated or incorrect design and poor enforcement of building work can lead to widespread damage and even large casualties during future earthquakes. Therefore, the need to disseminate knowledge to engineers regarding the repair of concrete is essential, namely reasonable design, repair or enhancement which includes the assessment of structural and modern knowledge of repair and strengthening techniques and appropriate method of implementing the structural rehabilitation [2].

Many researches were carried out in this area. Sarno et al. [3] have studied a seismic assessment of a reinforced concrete school building retrofitted with innovative braces. The existing frame was retrofitted through innovative buckling restrained braces (BRBs). The seismic performance of the as-built and consolidated structure was investigated through refined static and dynamic analyses, both linear and nonlinear. The nonlinear static analyses demonstrated that the use of BRBs is very efficient to enhance the global over-strength (about 30%) and energy dissipation capacity of the reinforced concrete frame under moderate-to-high magnitude earthquakes.

Hassaballa et al. [4] have conducted a seismic evaluation and retrofitting of existing Hospital building in Sudan. The building was constructed according to the design using one case of loads, this situation needs remedy. This paper suggested two solutions for this problem based on

strengthening the weak columns by inserting reinforced concrete shear walls. It was found that solution one solved the problem partially because some columns were still unsafe, but solution two solved the problem completely and all columns were safe. Ahmed et al. [5] have guided a study on the performance and strengthening of non-seismically designed concrete framed structure building under seismic loading conforming to Kingdom of Saudi Arabia`s Code. A shear wall coupled structure system is adopted as seismic strengthening option as the structure of building is found unsafe under the seismic loading. The seismic load and other loadings are adopted as conforming to ACI Code. The shear wall structure analysis results are compared with the complete frame structure building. It was found that the provision of shear wall is an appropriate strengthening technique for the building under seismic loading. Knowing that, there are other works on the rehabilitation of vulnerable structures, namely that of Davidovici [6, 7] on the rehabilitation of existing hospitals and schools as well as their strengthening with reinforced concrete walls. In Algeria, as in other seismic countries, several practical studies have been conducted on the rehabilitation of structures after each earthquake. Two experiences in rehabilitation made after the earthquakes of El Asnam 1980 and Boumerdes 2003 are worthy to be cited. In Algeria, despite the existence of recommendations [8] and a technical guide of repair or strengthening methods for structures [9], there is a lack of regulatory support for the study of rehabilitation. It is well known that the measures used to achieve ductility and toughness in structural elements is unique to each construction material and to each type of structural system for each building.

The purpose of this study is to present first, a summary of the rehabilitation method of Eurocode 8-3 [10]. Then we apply the measures indicated in the latter code by proportioning the structure adequately to rehabilitate an office building in Algeria, which was edified in low seismicity zone (zone I) according to the pre-amended Algerian Earthquake Regulations (RPA88) [12]. The amendments to Regulation in 2003 resulted in the production of a new regulatory seismic zoning and the zone was switched at medium scale zone IIa. Finally, the paper highlights the performance of the proposed solution for the strengthening using a nonlinear static analysis.

2. Method of Method of Rehabilitation According to the Eurocode 8-3

2.1. Information for Structural Assessment

According to the steps described by Eurocode 8-3 [10], the first step governing the structural rehabilitation begins with the collection of the general and historical information of the building, especially the required input data to begin the methodology rehabilitation.

2.1.1. General Information and History

In order to assess the earthquake resistance of existing structures, the input data shall be collected from a variety of sources, including:

- Available documentation specific to the building in question,
- Relevant generic data sources (e.g. contemporary codes and standards),
- Field investigations and, in most cases, in-situ and/or laboratory measurements and tests, as described in the following steps.

It should check between the data collected from different sources to minimize uncertainties.

2.1.2. Required Input data

The minimum input data required for the evaluation of the structure according to Eurocode 8-3 [10] are summarized as follow:

a. Identification of the structural system and its compliance with the regularity criteria in EC8-1 [11]. The information should be collected either from onsite investigation or from original design drawings, if available. In this latter case, information on possible structural changes since construction should also be collected.
b. Identification of the type of building foundations.
c. Identification of the ground conditions as categorized in EC8-1 [11].
d. Information about the overall dimensions and cross-sectional properties of the building elements and the mechanical properties and condition of constituent materials.
e. Information about identifiable material defects and inadequate detailing.
f. Information on the seismic design criteria used for the initial design, including the value of the force reduction factor (q-factor), if applicable.
g. Description of the present and/or the planned use of the building (with identification of its importance category, as described in EC8-1 [11].
h. Re-assessment of imposed actions taking into account the use of the building.
i. Information about the type and extent of previous and present structural damage, if any, including earlier repair measures.

The different types of analysis and different values of the confidence coefficients must be adopted according to the volume and quality of the gathered information.

2.2. Definition and Identification of Knowledge Levels

The type of allowable analysis and the appropriate confidence factor values, according EC8-3 [10] is based on three knowledge levels, namely limited knowledge (KL1), normal (KL2) and full (KL3). The factors

determining the appropriate knowledge level are:

- The geometry of the structural system and non-structural elements,
- Detailing of reinforcement in reinforced concrete and,
- The mechanical properties of the constituent materials.

The identification of the knowledge level of these factors is necessary to examine the following aspects:

i. Physical condition of reinforced concrete elements and presence of any degradation, due to carbonation, steel corrosion, etc.
ii. Continuity of load paths between lateral resisting elements.

2.3. Confidence Factors

To determine the properties of existing materials used in the calculation of capacity, and when this one must is to be compared with demand for safety verification, the average values obtained from in-situ tests and from the additional sources of information shall be divided by the coefficient of confidence, CF, given by the EC8-3 [10], which is the appropriate knowledge level that complies with the requirements. However, in order to compute the force capacity in terms of the ductile components, intended to be used in the safety check, the mean value properties of existing materials shall be multiplied by the confidence factor CF for the appropriate knowledge level.

2.4. Vulnerability Assessment

Assessment is a quantitative procedure for checking whether an existing undamaged or damaged building will satisfy the required limit state appropriate to the seismic action under consideration, as specified in EC8-1 [11].

3. Description of Building

From original outline construction built drawings as a source of information the evaluation of the structure can be derived.

3.1. General Information and History of the Existing Building

The basic documentation available of the structure is original design specifications of the structural components shown in Fig. 1 and Table 1. The relevant sources of generic data are reached based on Algerian Earthquake Regulations RPA88 [12] and the French Concrete Code CCBA 68 [13] used at the time. Regarding inexistent field investigations, but currently the foundation of the built structure is loose ground soil.

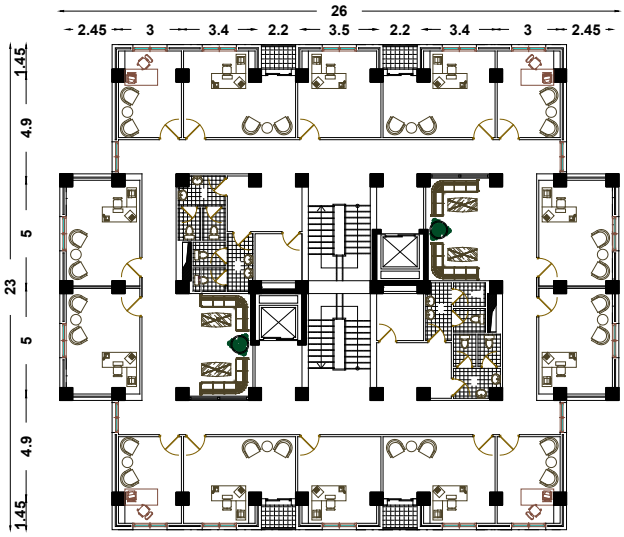


Figure 1. Plan of old building

Table 1. Sizes of beams and Columns

Components	Storey	Sizes (cmxcm)
Columns	1, 2, 3, 4	40x40
	4, 5, 6, 7	35x35
Beams	Primary	30x40
	Secondary	30x35

3.2. Necessary Input Data of the Existing Building

The necessary input data for the structure assessment according to Eurocode 8-3 [10] are:

a. The classification and identification of the structural system1 and of its compliance with the regularity criteria according to Algerian Earthquake Regulations RPA99/V2003 [1], are:
   - The administrative building is of vital importance of usage classified in group III.
   - Its structural system is composed by resisting frames,
   - The arrangement of these structural elements largely meets the criteria of regularity in code RPA99 / V2003 [1].
b. The existing foundations of the structure are strip footing
c. The soil is defined as loose soil (S3);
d. The value of the behavior factor (q factor) used in the initial design is equal to 4.

To select the type of permissible analysis and the appropriate values of the confidence factors, according to EC 8-3 [10], the established knowledge level is Level 2 corresponds to the normal knowledge (KL2).

3.3. Identification of Geometry, Details and Materials

3.3.1. Geometry

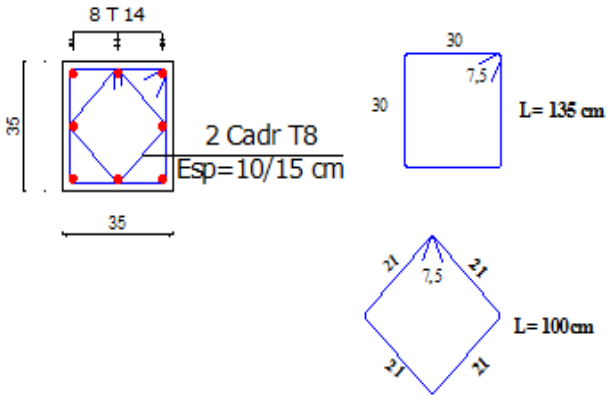
The bracing system in both directions is provided by the resisting frames systems. The direction of floor slabs considered as rigid diaphragm and the various quotes between axes are illustrated in Figure 1. The dimensions of the existing cross-sectional area of beams and columns are shown in Table 1.

3.3.2. Details

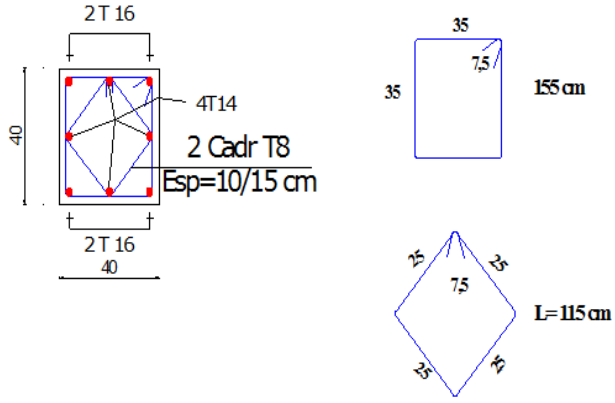
The amounts of longitudinal and transverse reinforcement and their detailing for columns and beams are illustrated in Fig. 2 and Fig. 3. The percentage of total longitudinal reinforcement in beams is fitting with that required by the RPA99 / V2003 [1].

3.3.3. Materials

In order to assess the current mechanical properties of concrete, a non-destructive testing has been performed. The measured compressive stress f_{ck} is 16 MPa, while the computed value of f_{ck} is 25MPa. Moreover, steel offers good resistance to tensile stresses with a value of f_{cy} equal to 400 MPa.

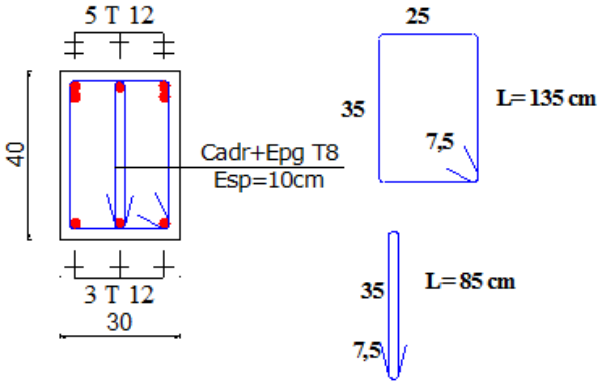


Columns (35x35) cm²

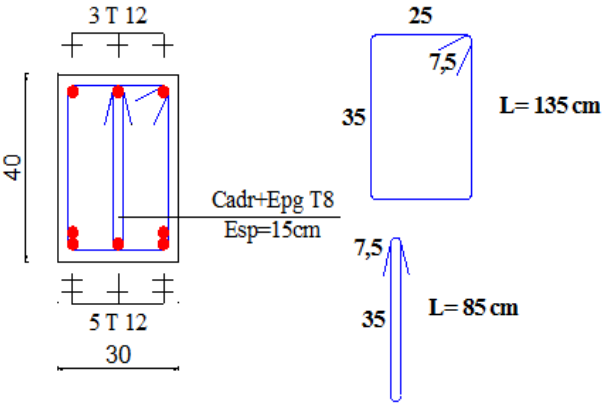


Columns (40x40) cm²

Figure 2. Detailing of columns

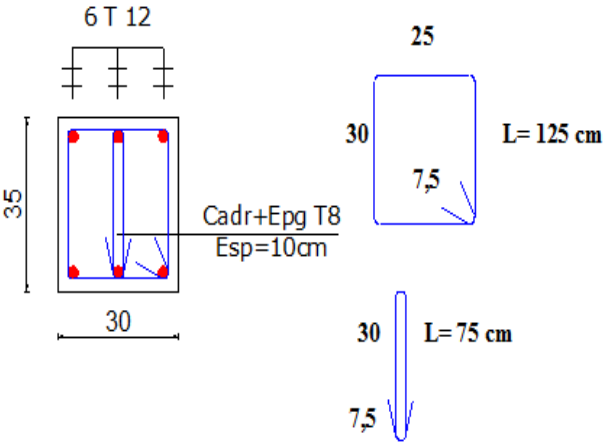


At end



At mid-span

(A) Primary beams



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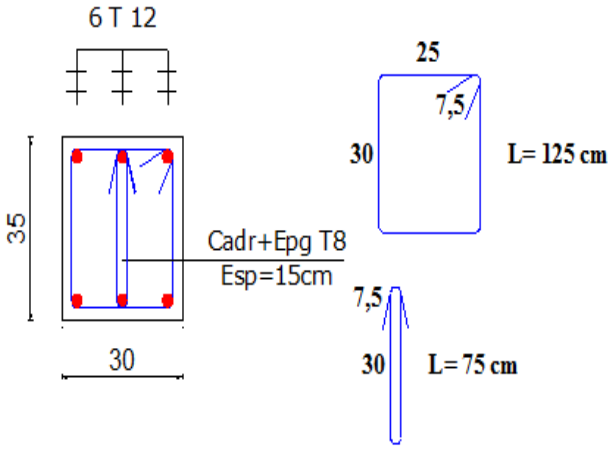


At mid-span

(B) Secondary beams

Figure 3. Detailing of beams

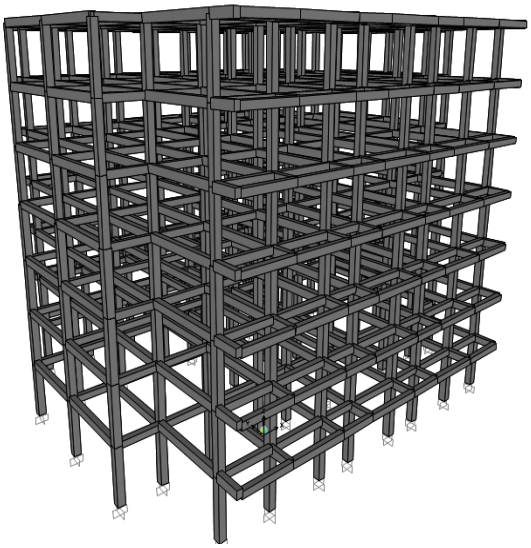


Figure 4. Building Modeling

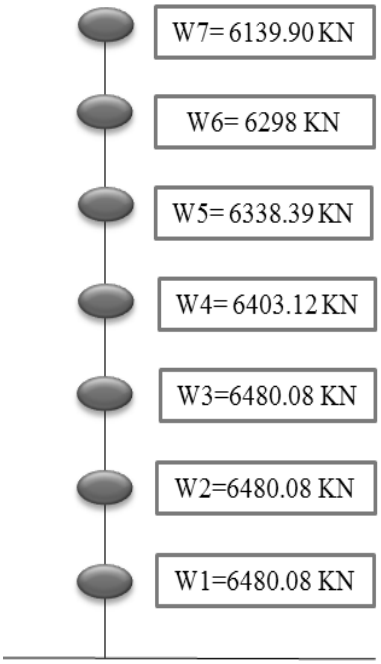


Figure 5. Weight of each floor

4. Evaluation of Vulnerability of Building

The evaluation of the seismic vulnerability of the building is performed using the linear dynamic method with SAP2000 software. After modeling of the structure, the natural periods of vibration, and participation of the masses as well as the Eigen modes are estimated. Then, the seismic force is determined at the base using the equivalent static method. Finally, the inter-storey drifts then the lateral displacement of the whole structure are checked.

4.1. Building Modeling

The modeling shown in Fig. 4 by SAP2000 software enables to study the elastic structure. Hence, the model considers the selected members of the structure according to the following concept:

- The Beams and columns will be modeled by bars "FRAME";
- The Floors have infinite stiffness in their plane; this is done by assigning an element "DIAPHRAGME";
- The Mass of each floor is concentrated at its gravity center.
- The load path due to each structure member allows the weight evaluation of each floor as illustrated in fig. 5. The total weight of the structure was found equal to 44619.65 KN.

4.2. Natural Periods

In this section the natural vibration periods are determined, as well as the modal mass participation and mode, using the SAP2000 software. For the three main directions of the structure the values of fundamental periods are:

T1= 1.31sec for the 1st period

T2= 1.24sec for the 2nd period

T3= 1.22 sec for the 3rd period

The first two modes are translational modes (which is acceptable), and the third mode is a torsional mode. These periods shall not exceed the fundamental period of the structure TRPA increased by 30%, which is established from the empirical formula of RPA99 / V2003 [1]. 0.55 sec is the estimated value of the TRPA. The results obtained show that the actual periods in both directions are far beyond 1.3TRPA. This is due to the flexibility of the construction which confirms its vulnerability.

4.3. Determination of the Seismic Force

The seismic force evaluation determined by the SAP 2000 software were found equal to 2627,904 kN in the x direction and 2648,089 KN in the y direction. These forces shall not be less than 80% of the prescribed seismic forces VRPA determined by the equivalent static method. The values of these forces are 4747.79 KN in the x direction, and 4945.61 in the y direction. Comparing these forces in each direction with the actual seismic forces shows that they are beneath the values required by RPA99 / V2003. The gap exceeds by 30% of that obtained by the empirical formula. This confirms the vulnerability of the structure as it has been proved in the verification of the fundamental period. This also shows that the original design seismic force in zone I was very low according to former RPA 88 [12] regulation.

According to the study of vulnerability by the linear dynamic analysis, the studied construction showed a glaring deficiency in the period and the design base shear. This requires seismic retrofit of the construction is essential to reduce its vulnerability.

5. Study of the Rehabilitation of the Building

Decision should be focused on how to intervene based on the conclusion of the condition assessment of structural vulnerability. The type of remedial intervention, its technique, scale and urgency, must refer to the report from condition assessment which provides information of the actual condition of the building [10].

5.1. Technical Criteria

It should be taken into account the following technical criteria [10]:

a. repair of all identified structural defects in appropriate manner to ensure safety of the structure;
b. In case of highly vertical mass or stiffness irregularity in the existing building, structural regularity should be improved as much as possible, both in elevation and in plan;
c. The required characteristics of regularity and resistance can be achieved by either modification of the strength and/or stiffness of an appropriate number of existing components, or by the introduction of new structural elements;
d. Increase in the local ductility supply should be affected where required;
e. The increase in strength after the intervention should not reduce the available global ductility;

5.2. Type of intervention

An intervention may be selected from the following indicative options [10]:

a. Local or overall modification of damaged or undamaged elements (repair, strengthening or full replacement), considering the stiffness, strength and/or ductility of these elements;
b. Addition of new structural elements (e.g. bracings or infill walls; steel, timber or reinforced concrete belts in masonry construction; etc.);
c. Modification of the structural system (removal of some structural joints and vulnerable elements; widening of joints; modification into more regular and/or more ductile arrangements);
d. Addition of a new structural system to sustain some or all of the entire seismic action;
e. Possible conversion of existing non-structural elements into structural elements;
f. Introduction of passive protection devices through either dissipative bracing or base isolation;
g. Mass reduction;
h. Restriction or alteration of the building usage;
i. Partial demolition;

One or a combination of several options of retrofit strategies can be chosen. It should, in any case take into account the effect of changes in structure on the foundation.

5.3. Proposed Solution

In order to increase the resistance capacity and ductility of the structure, the limited funding has restrained the strengthening of the resisting frames of building to the addition of new shear walls in the original plan of the building as shown in Fig. 1. Concrete walls should be integrated at the periphery of the building, so to preserve the integrity of the interior of the building and conserve a reasonable regularity in plan and elevation. The compressive strength used for shear walls for is equal to 25 MPa.

The specific concern is to ensure that adjustments brought to the building configurations can satisfactorily carry lateral loads suitably and in harmony with the

existing structure. The proposed solution is illustrated in fig. 6.

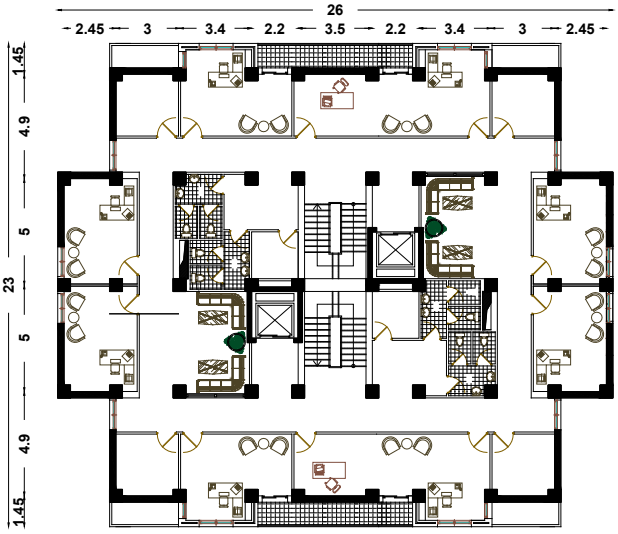


Figure 6. Plan of strengthening building

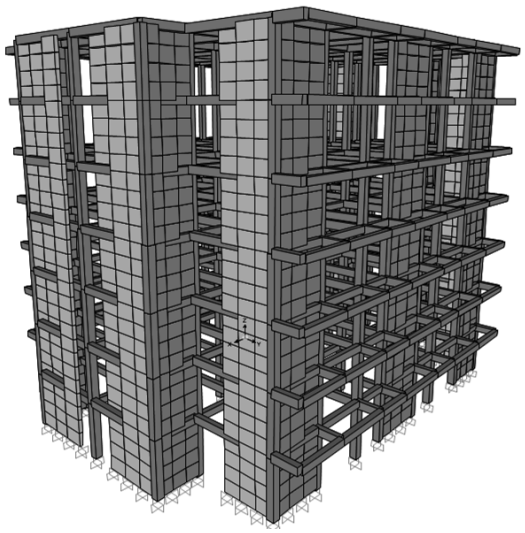


Figure 7. Modeling of strengthening building

5.4. Dynamic Study of the Building with the Proposed Solution

5.4.1. Modeling of the structure

The new shear walls are already integrated and arranged in accordance to the recommendation of the Algerian Earthquake Regulations (RPA 99 / V2003 [1] concerning the stability of the structure (Figure 7). Non-structural elements are considered as dead loads only.

5.4.2. Checking dynamic characteristics of the building

The results obtained using the SAP2000 software have given specific periods $T_X = 0.52$ sec and $T_Y = 0.42$ sec for the new structure in x direction, and y direction respectively, While the estimated value of the fundamental period TRPA is 0.46 sec. These results show that the actual periods T_X and T_Y are less than the factored fundamental period by 30%, according to the RPA99 / V2003 code (T_X and T_Y <1.3TRPA = 0.56 sec). This shows that the shear walls placement is improving the resisting capability of the building.

Determined seismic resulting forces of the retrofitted structure are 3420 KN and 3603 KN in X and Y directions respectively. These forces must not be less than 80% of the prescribed seismic forces V_{RPA} determined by the equivalent static method. The values of these force are the same in both directions (V_{XRPA} and V_{YRPA}) are equal to 3772 KN. Comparing the forces in each direction shows that the actual resisting seismic forces are greater than those required by RPA99/V2003. This shows that the undertaken structural interventions aimed at stiffening the building were adequate.

6. Performance of the Strengthening Studied Building

The results obtained by push-over (non-linear static analysis) analysis elucidated as capacity curves using SAP 2000 software enabled a comparison of the nonlinear behavior between the strengthened structure and the old one.

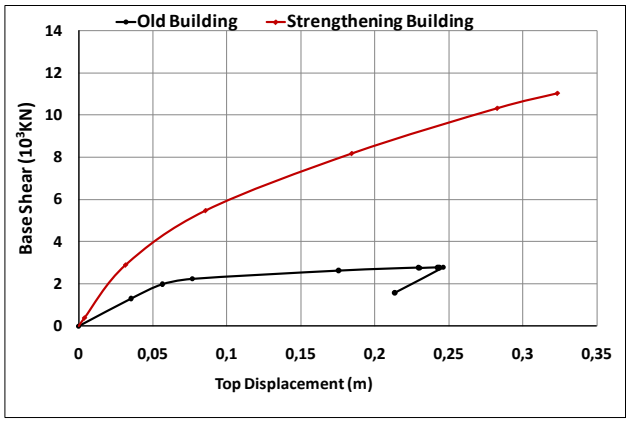
6.1. Shear Force

Fig. 8A highlights a confrontation between the old building capacity curves before and after strengthening the structure by adding reinforced concrete bracing walls in both directions. This figure clearly shows the importance of the adopted strengthening in terms of base shear, where the strengthened structure capacity curve corresponding to that modification is far more exceeding the one of the non-strengthened structure. In the original building, the value of the base shear is 2783.031KN which represents less than 65% of the value found using the equivalent static method in the x direction (V_X = 3675,054KN). This value increases to 11020.129KN for the strengthened structure which is about four fold increase in computed force for the original building, and more than three times the strength value when using the equivalent static method for the same direction (V_X = 3772,27KN). The same observation is noticed for improving the behavior of the structure for the y direction in Fig. 8B. Therefore, it can be noticed that the overall resistance capacity of the strengthened structure is improved more than three times compared to the original structure.

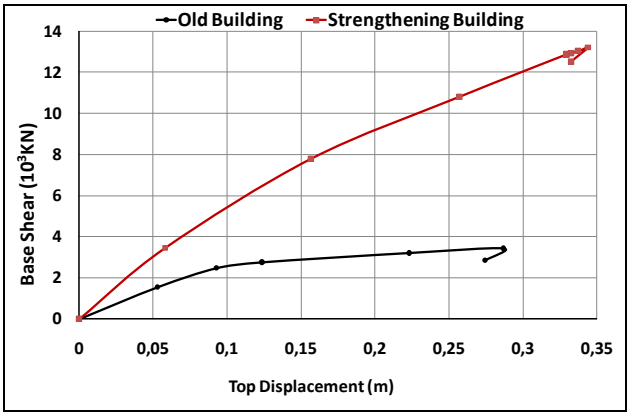
6.2. Displacement

From Fig. 8A, in terms of roof displacement, the capacity curve of the original structure shows that the final

displacement reaches a corresponding value of 0.24m, which is enhanced to 0.34m for the strengthened structure, which represents approximately a 15% increase. For the y direction (Figure 8B), the displacement reached a value of 0.29 m for the non-strengthened structure, which is increased to 0.33m with a rate of 10% for the strengthened structure. Accordingly, the structure deformation capacity is not greatly improved is still in a range that does not exceed 10 to 15%.



(A) Capacity curves in x direction

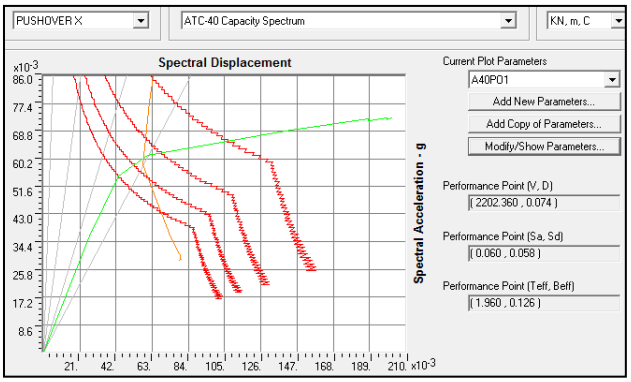


(B) Capacity curves in y direction

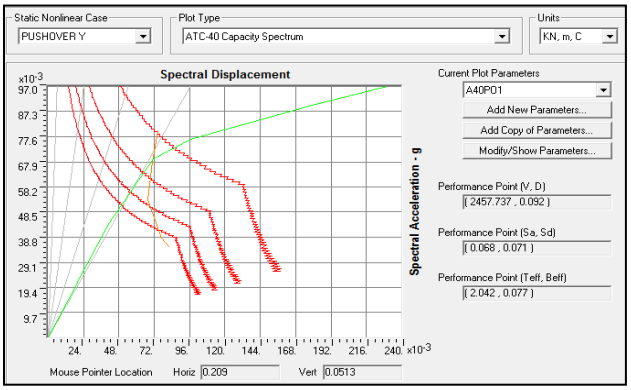
Figure 8. Comparison between the capacity curves before and after strengthening the structure

6.3. The Structure Performance Point

The performance point enables to make several considerations on the structure behavior according to the earthquake from the integration of regulatory spectrum response corresponding to the current seismic zone on the capacity curve of the structure [11]. In this case, the junction is almost at the limit of elastic behavior of the structure in both directions as shown in Fig. 9 for the old structure, and Fig. 10 for the strengthened one. Table 2 shows a comparison between the performance point values obtained in terms of shear, displacement and damping ε_{eff} for the structure before and after strengthening. According to this table, we observe that the values for the original structure are lower than the ultimate values obtained previously which furthermore confirms that the structure is vulnerable.

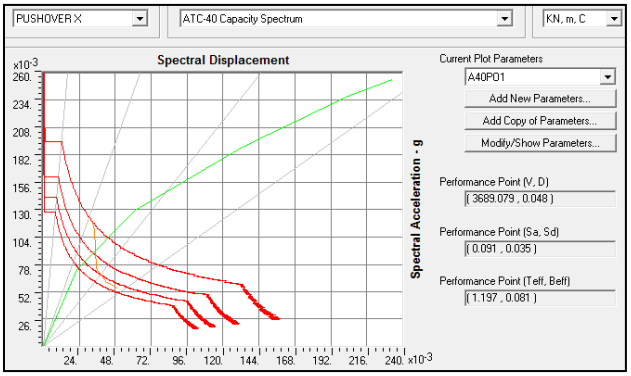


(A) X direction

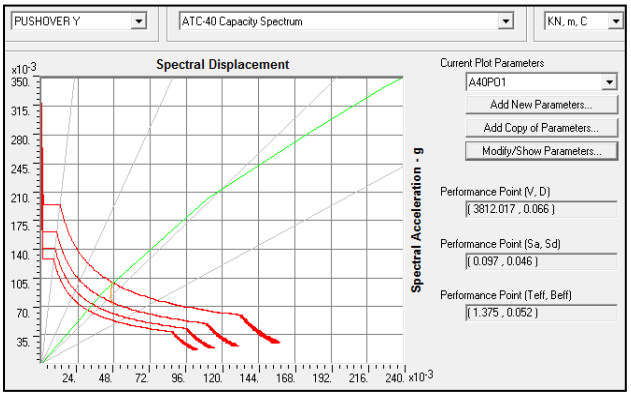


(B) Y direction

Figure 9. Performance point for the structure before strengthening



(A) X direction



(B) Y direction

Figure 10. Performance point for the structure after strengthening

Table 2. Comparison between the performance point values for the structure before and after strengthening

		Before strengthening	After strengthening
X direction	Shear force V (KN)	2202,36	3689,08
	Damping εeff	0,126	0,081
Y direction	Shear force V (KN)	2456,74	3812,02
	Damping εeff	0,077	0,052

However, the values obtained for the retrofitted structure is well above that found previously for base shear force and control displacement. As a consequence, the performance point values of the strengthened structure show a clear improvement in the resistance and damping that is greater than the initial values of the original structure by 80%.

7. Conclusions

The study of vulnerability using the linear dynamic analysis, studied building showed a great deficiency into the dynamic characteristics, namely its natural period and the seismic base shear, which requires rehabilitation. A brief presentation of the rehabilitation method of Eurocode 8-3 [10] was exposed. An adopted strengthening solution of construction was proposed. The highlighting of the performance of the proposed solution for the strengthening is performed using a non-linear static analysis.

The study of the performance of the building before and after strengthening using push-over analysis enables to draw the following conclusions:

- The overall resisting capacity of the strengthened structure is improved by more than three times compared to the old structure.
- The structure deformation capacity is not greatly enhanced, but remains within a range that does not exceed 10 to 15%.
- The performance point values after of the strengthened structure show a clear improvement in the resistance and damping that exceed 80% of the initial values of the original structure.

REFERENCES

[1] RPA-99/ 2003, 2004, Règles parasismiques Algériennes 1999 - Version 2003. DTR-BC 248 - Centre National de Recherche Appliquée en Génie sismique (CGS), Alger.

[2] Penelis G.G., Kappos A.J, Earthquake resistant concrete structures, Edition E & FN SPON, 1997.

[3] Sarno L. Di and Manfredi G., 2009, Seismic assessment of a RC school building retrofitted with innovative braces, Concrete Repair, Rehabilitation and Retrofitting II – Alexander et al (eds), 2009 Taylor & Francis Group, London, pp. 1149-1155.

[4] Hassaballa A. E., Ismaeil M. A., Fathelrahman M. A., 2014, Seismic Evaluation and Retrofitting of Existing Hospital Building in the Sudan, Open Journal of Civil Engineering, 4, 159-172.

[5] Ahmed M., Nazar S., Islam S., Khan R. A., 2014, Seismic Performance and Strengthening Study of Concrete Frame Structure Building, Journal of Multidisciplinary Engineering Science and Technology (JMEST), Vol. 1 (5), pp. 478 - 482

[6] DAVIDOVICI Victor, réhabilitation des hôpitaux existants, 2007.

[7] DAVIDOVICI Victor, renforcement par mur en béton armé, 2006.

[8] Recommandations techniques pour la réparation et le renforcement des ouvrages, Algérie.

[9] Catalogue des méthodes de réparation et de renforcement des ouvrages - CGS- 1992, Algérie.

[10] EN 1998-3:2005 E, Eurocode 8: Design of structures for earthquake resistance Part 3: Assessment and retrofitting of buildings, European Committee for Standardization, Brussels.

[11] EN 1998-1:2004 E, Eurocode 8: Design of structures for earthquake resistance Part 1: General rules, seismic actions and rules for buildings, European Committee for Standardization, Brussels.

[12] RPA-88, Règles Parasismiques Algériennes, Centre National de Research Appliquee en Genie Parasismique (CGS), 1989. DTR, Algiers, (in French).

[13] CCBA 68, Règles techniques de conception et de calcul des ouvrages et constructions en béton armé, PARIS 1968 (in French).

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A Comparative Study on Clay and Red Soil Based Geopolymer Mortar

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Abstract Geopolymer mortar is cement less which is gaining popularity globally towards the sustainable development. It can be produced from mineral admixtures such as fly ash, clay, red soil with user-friendly alkaline-reagents. Production of Ordinary Portland Cement (OPC) requires large amount of energy as well as carbon footprint. It is shown that OPC emits approximately 5% of global CO_2 emissions annually, which works out to nearly more than ½ ton of CO_2 emission for every one ton production of OPC. So it is badly needed to reduce the global CO_2 which has encouraged the researchers to search alternative sustainable building materials those are available in locality with lower embodied energy and carbon dioxide emissions. Clay and red soil are the best selection for that and both are usable as an eco-friendly building materials also available in locality. So an attempt has been made to explore the possibility of using clay and red soil based mortar in construction industry. The composition and microstructure were characterized by x-ray fluorescence (XRF), scanning electron microscopy (SEM) &particle size analyzer. Studies were carried out for both materials with respect to compressive strength, ultrasonic pulse velocity, effective porosity and co-efficient of absorption. The results indicated that geopolymer mortar with clay and red soil can be used as an alternate construction material in the construction industry.

Keywords Geopolymer Mortar, Clay, Red Soil, Characterization, Performance, Sustainability & Application

1. Introduction

Geopolymer term was first applied by the Davidovits[1], which is alkali aluminosilicate binders formed by the alkali silicate activation of aluminosilicate materials. Geopolymer and Alkali-activated cements are often confused, which were originally developed by Glukhovskyin the Ukraine during the 1950s [1]. Recently research is shifting from the chemistry to engineering and commercial application of geopolymer for sustainable development. It has been shown that geopolymer concrete has good engineering properties [2]. This is a cementitious material which is better alternate to cement and it possesses the advantages of rapid strength gain, elimination of water curing, good mechanical and durability properties. Moreover it is a binder material which is produced from an alumino-silicate activated in a high alkali solution [3].

Construction is the 2nd largest industry in this world. Embodied energy, carbon emission, economy, utility, durability and comfort are the main concerns of current classical building design. Cement mortar is one of the integral parts of a building and it is one of the primary binders for classical building design to produce the mortar as well as concrete. So for, the development of infrastructure facilitates the demand of OPC is increasing day by day. Thus the use of OPC to create modern infrastructure has come at the cost of significant quantities of CO_2 released to the atmosphere [4].

Chemically, OPC is a mixture of tri- and dicalcium silicate (Ca_3SiO_5 and Ca_2SiO_4, respectively; sometimes written $3CaO{\cdot}SiO_2$ and $2CaO{\cdot}SiO_2$ or as C3S and C2S in cement chemist's notation) [5]. OPC production relies on the calcination of limestone ($CaCO_3$) and silica (SiO_2) at high temperatures. The production of 1 ton of cement emits roughly ½ ton of CO_2 as a direct result of this chemical reaction (Hardjito, Wallah, Sumajouw, &Rangan, 2004):

$$5CaCO_3 + 2SiO_2 \longrightarrow^{1450^{\circ}C} Ca_3SiO_5 + Ca_2SiO_4 + 5CO_2$$

When the tri- and di-calcium silicates are hydrated, producing calcium silicate hydrates (C–S–H, in cement chemist's notation) that are the strength-bearing phase of OPC and $Ca(OH)_2$:

$Ca_3SiO_5 + Ca_2SiO_4 + 10H_2O \rightarrow 2(3CaO{\cdot}2SiO_2{\cdot}3H_2O) + 4Ca(OH)_2$ + 173.6 kJ heat [5].Thus the production of OPC not only releases the significant amount of carbon dioxide to the atmosphere but also consumes huge amount of

natural resources and energy.

In the fast growing construction world it is essential to find alternatives to cement mortar and concrete for making environment friendly structure. One of the alternatives to produce more eco-friendly mortar is by-product materials such as fly ash, red soil, meta-kaolin or clay.

There are two main constituents of geopolymer mortar, source materials and the alkaline liquids. The source materials based on alumina-silicate should be rich in silicon (Si) and aluminium (Al). These are natural minerals such as kaolinite, clays, etc. or by-product materials such as red soil, fly ash, silica fume, slag, rice-husk ash [5]. The choice of the source materials mainly depends on factors such as availability, cost, and type of application and specific demand of the end users. The alkaline liquids are from soluble alkali metals that are usually sodium or potassium based. The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. [6].

This paper describes clay and red soil based geopolymer mortar. However no specific publications are available concerning the performance of red soil and clay based mortar for eco-friendly construction. So this paper is devoted to explore the possible application of red soil and clay based geopolymer mortar for sustainable construction in future practice.

2. Experimental Work

2.1. Materials Used

Clay and Red soil: Collected from Karaikudi, Tamil Nadu was used for casting the specimen.

Fine Aggregate: Locally available River sand (local) passing through 4.75mm mm sieve was used.

Binder: Combinations of sodium hydroxide (NaOH) and Sodium Silicate (Na_2SiO_3) are employed to achieve the activation of the geopolymer mortar. The chemical composition of Sodium Silicate is: Na_2O-14.922%, SiO_2-43.247% and H_2O -41.83% [7]. 14M concentration binder was used with a fixed binder to soil ratio 0.4.

Water: Portable water is used with pH 7 to 8.5; Cl^- = 40 ppm, Hardness = 240 ppm and distilled water was used for making binder [7].

Calcium Oxide (LR grade): (1% sample weight) was used for rapid setting of mortar.

2.2. Elemental and Morphological Characterization

Elemental composition of red soil and clay were determined by X-Ray Fluorescence (XRF) analysis, are given in Table 1.

Table 1. Composition of red soil and clay as determined by XRF (% Mass)

Composition	Clay	Red Soil
SiO2	53.221	61.563
Al2O3	25.311	22.579
Fe2O3	14.823	8.742
CaO	0.803	0.390
MgO	3.754	4.283
MnO_2	0.080	0.208
TiO2	2.009	2.236

Table 2. Percentiles of clay and red soil

% Tile	Clay(nm)	Red soil(nm)
10.00	165.2	139.6
20.00	200.5	166.9
30.00	228.9	190.8
40.00	252.3	214.1
50.00	272.9	238.1
60.00	292.2	263.5
70.00	311.0	292.8
80.00	332.0	329.0
90.00	360.0	384.0
100.00	382.0	429.0

From Table 1 it has been observed that both clay and red soil are having more than 70% of aluminosilicate materials and can be used for making geopolymer concrete. Percentiles of clay and red soil were determined by particle size analyzer are given in Table 2. Particle size distribution for clay and Red Soil are showing in Fig.1

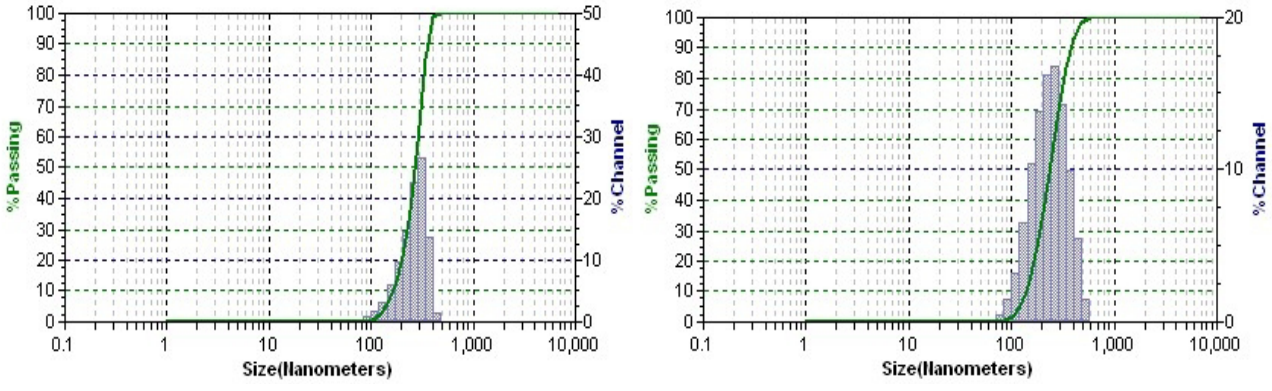

Figure 1. Particle size distribution for Clay (Left) and Red Soil (Right)

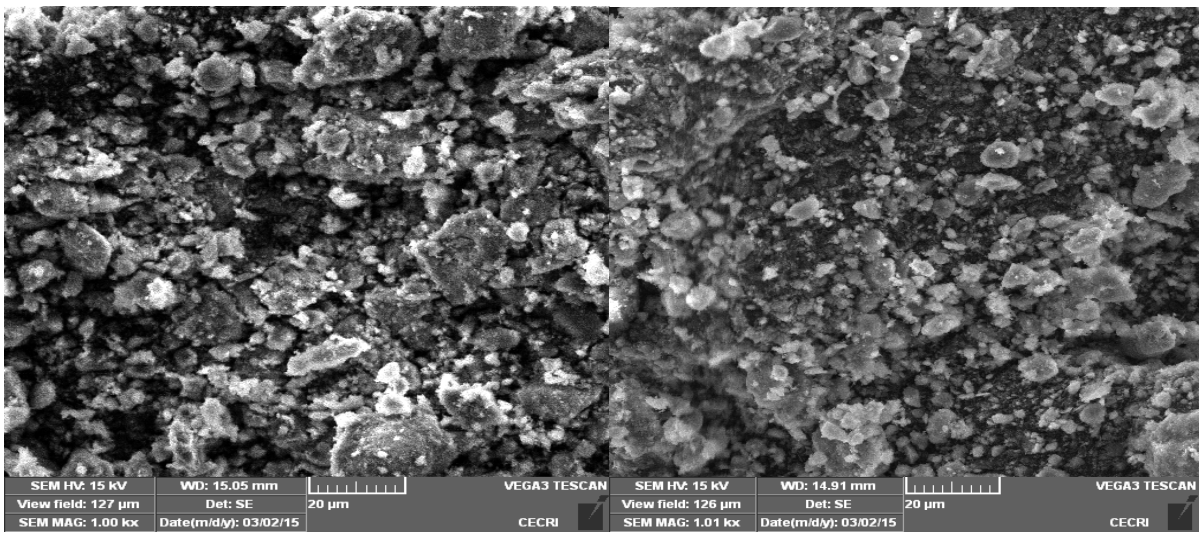

Figure 2. SEM Image of Clay (Left) and Red Soil (Right)

From Fig.1 it is observed that the particle size ranges from 165.2nm to 382nm, 139.6nm to 429nm for clay & red soil respectively. Fig.2 shows the scanning electron micrographs of red soil and clay respectively. Both particles are spongy in shape and have a wide range of particle size or diameter as depicted from particle size analyzer.

2.3. Mixing and Preparation of Specimen for Making Geopolymer Mortar

Red soil and clay with a mixture of alkaline activators namely sodium silicate and sodium hydroxide (NaOH) solution at a fixed Alkaline activator/soil ratio 0.4 were used to prepare a clay and red soil based geopolymer at constant (NaOH) concentration of 14M. Clay or red soil to fine aggregates ratio was maintained at 1:3.Total additional water for clay and red soil are approximately 12% and 6 % of total sample weight

Addition of calcium oxide was approximately 1% of sample weight. A ratio of sodium silicate solution-to-sodium hydroxide solution, by mass, of 2.5 was used [8]. The sodium silicate solution and the sodium hydroxide solution were mixed together at least 24 hours prior to casting of the specimens.

The fresh geopolymer mortar was used to cast cubes of size 50mm x 50mm x 50mm to determine its compressive strength, ultrasonic pulse velocity, water absorption as well as co-efficient of water absorption. Each cube specimen was cast in three layers by manual compaction as well as by using vibrating table. Each layer received 25-30 strokes of compaction by rod followed by further compaction on the vibrating table.

2.4. Curing and Exposure Conditions

After casting, the specimens were allowed to set for 24hrs in moulds. Then, the specimens were removed from the molds and heat cured in oven at 60-70^0 C for 24 hours. After that, the specimens were cured in room temperature until they reached the 7th, 14th and 28th days of age.

3. Tests Carried Out

3.1. Ultrasonic Pulse Velocity (UPV)

UPV is a recognized non-destructive evaluation test to qualitatively asses the homogeneity and integrity of concrete and mortar. This test essentially consists of measuring travel time, T of ultrasonic pulse of 50 to 54 kHz, produced by an electro-acoustical transducer, held in contact with one surface of the concrete member under test and receiving the same by a similar transducer in contact with the surface at the other end. With the path length L, (i.e. the distance between the two probes) and time of travel T, the pulse velocity (V=L/T) is calculated **[9].**The cube samples were subjected to UPV test prior to compression test and the values were recorded.

3.2. Compressive Strength

The compressive strength test of concrete is one of the most important and useful properties of concrete. In most of the structural applications concrete is employed primarily to resist the compressive stresses. The compressive strength is frequently used as a measure of these properties. Mortarcube specimens of 50mmx 50mm x50mm were cast for both clay and red soil with a fixed percentage and concentration of binder. After a specified period, specimens are subjected to compression test by using universal testing machine of 100T capacity at a loading rate of 140kN/min.

3.3. Test for Water Absorption, Specific Gravity and Permeable Voids (ASTM C642-90)

This test was done as per the procedure given in ASTM C 642-90 by oven drying method for this test

50mmx50mmx50mm cube was cast. After 48hours of de-molding, the specimens were kept in air and thermal curing. At the end of curing periods, the specimens were kept in open atmosphere for surface drying. Then the specimens were dried in an oven at a temperature of 100+5°C for 48hours and allowed to an accuracy of 1 gm using a standard weighing balance.

Record the weight of dried specimens as Wd[8].

Immerse the specimens in water at room temperature (28°C) for minimum 48 hours. Then the surface moisture was removed with a towel or cotton and weighed. This weight is designated as Ws. After that the specimens were immersed in tap water in a container and boiled for 5 hr at 60 ^{0} C. Allowed to cool for natural loss of heat for 14 hours and then surface moisture was removed and reweighed. This is designated as W_b. The suspended weight of the specimens kept in water is taken as Wi. Then the following parameters were calculated as follows:

$$\% \text{ Water Absorption} = (Ws-Wd)/Wd$$

$$\text{Bulk Sp.Gravity(Dry)} = Wd/(Wb-Wi)$$

$$\text{Apparent Sp.Gravity} = Wd/(Wd-Wi)$$

$$\text{Permeable voids (\%)} = (Wb-Wd)/(Wb-Wi)$$

3.4. Co-efficient of Water Absorption

The Coefficient of water absorption test was conducted as per ASTM C642-97. This is measured by the rate of uptake water or capillary absorption of water by dry concrete over a period of 48 hours. The four sides of the cubes (50mm X50mm X 50mm) specimens were sealed with epoxy except top and bottom sides, so that the water absorption is through unidirectional & capillary action takes place from the bottom sides only. Initially the weight of the dry specimen was taken and then placed in a plastic tray filled with water up to 1/3rd height of the specimen. Then the absorption of water was measured at different time intervals [8].

This is calculated from the formula:

$$\text{Coefficient of absorption } Ka = (Q/A)^2 \times (1/t)$$

Where Q = Quantity of water absorbed by the oven dried specimen in time

$$t = 48 \text{ hours } (172800 \text{ second}).$$

A = Total surface area of concrete specimen through which water penetrates.

A lower value of Ka indicates a higher degree of imperviousness of concrete for water penetration.

4. Result & Discussion

4.1. Ultrasonic Pulse Velocity (UPV)

Bar chart showing the comparison of ultrasonic pulse velocity for red soil and clay based geopolymer mortar which is given in the Fig.3. It is observed that red soil based mortar has shown higher UPV value than clay based mortar.

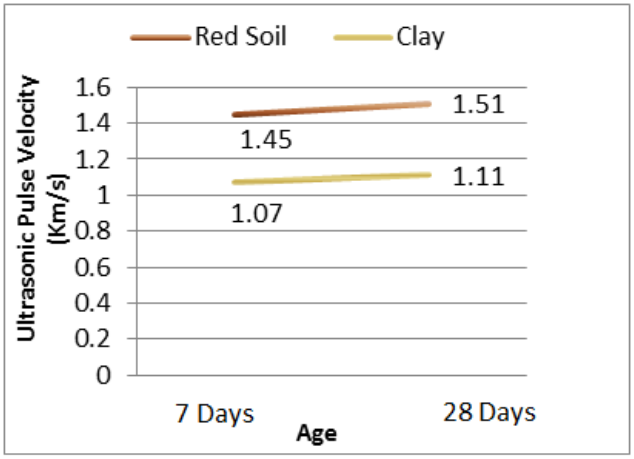

Figure 3. Ultrasonic Pulse Velocity for red soil and clay geopolymer mortar

4.2. Compressive Strength

The result of compressive strength 7, 14 and 14 days are obtained for clay and red soil mortar cubes are reported in Table 3. From the table, it is found that the compressive strength increase with increasing the curing period. Red soil specimen has shown higher compressive strength than clay specimen.

Table 3. Compressive strength value for red soil and clay mortar

Specimen Type	Average compressive strength (Mpa)		
	7 days	14 days	28 days
RGPM	3.03	6.38	7.73
CGPM	2.44	4.08	4.55

N: B:-RGPM: Red Soil Geopolymer Mortar, CGPM: Clay Geopolymer Mortar

4.3. Test for Water Absorption, Specific Gravity and Permeable Voids (ASTM C642-90)

The results for Water absorption, Specific gravity and Permeable voids are tabulated in Table 4. From this result it is shown that red soil based mortar absorb less water as well as less voids compare to clay based mortar.

Table 4. Water absorption, Specific gravity and Permeable voids

Name of the Test	Red soil	Clay
Absorption of water (%)	8.0	11.13
Bulk sp. Gravity (dry)	2.02	1.95
Apparent sp. Gravity	2.57	2.78
Permeable voids (%)	21.4	29.85

4.4. Test for Co-efficient of Absorption

The average value of co-efficient of absorption for both

clay and red soil are presented in Table 5. From the table it is observed that, the coefficient of water absorption for red soil cube is found to be less when compared to clay. Also from Fig.4 it has shown that clay based mortar has shown higher weight gain compared to red soil mortar with a specific time interval.

Table 5. Co-efficient of absorption for red soil and clay

Time(t)	Red Soil	Clay
3600 seconds	When t= 1hr or $2.03x10^{-8}$ (m^2/s)	$4.2 x10^{-8}$ (m^2/s)
172800seconds	When t=48 hours or $5.38 x10^{-10}$ (m^2/s)	$8.77 x10^{-10}$ (m^2/s)

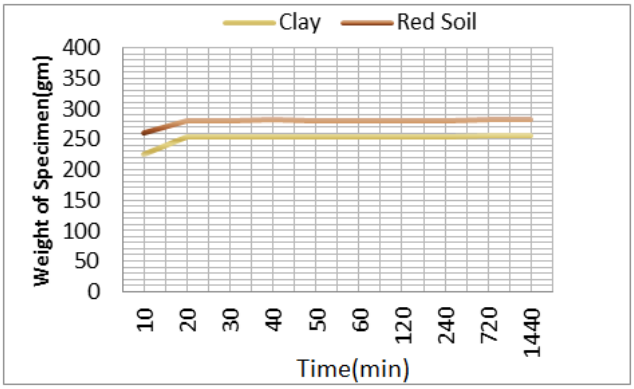

Figure 4. Weight of the specimens with respect to time

5. Potential Applications and Sustainability

For sustainable engineering propose it is possible to develop various masonry blocks by using locally available clay and red soil materials without the use of conventional cement and thermal input. Fast and simple method can be adopted for making bricks, pavements (low traffic), lightweight aggregates, roofing tiles and glass-ceramics and clay liners in geotechnical applications [10].

Previous studies have shown that embodied energy required for making soil based bricks are 5 to 15 times less than that of fired bricks. And the pollution emission will also be 2.4 to 7.8 times less than fired bricks [11].Some properties of conventional bricks are shown in Table 6. Furthermore compared to conventional bricks geopolymer brick has less breakage, better shape, use of local material, saving of fuel and also helps in improving the environment. The strength of the geopolymer bricks is as high as 5-8 MPa. Water absorption is less than 12%.

Table 6. Properties of conventional bricks [12]

Particulars	Conventional bricks
Strength	2-4 MPa
Shape & size	Non uniform & irregular
Water absorption	18-25%
Average Density	m^3

6. Conclusions

The following conclusions were drawn from the above investigation:

- Compared to ordinary Portland cement mortar red soil and clay based mortar have shown lower performance but in future these are potential material for replacing the use of OPC in infrastructure development[14, 15].
- By changing or modifying the various parameters it is possible to improve the performance of these materials which plays an important role for eco-friendly construction. Moreover between two materials, the red soil-based geopolymer mortar has shown better performance than clay based mortar. So this is one of the potential green materials for sustainable construction in future.
- Also as an energy efficient materials these geopolymer mortar do not have any Portland cement, so they can be considered as less energy intensive, since Portland cement is highly intensive energy material next only to Steel and Aluminum [17, 18]. Moreover these geopolymer mortars utilize the locally available materials for producing the binding material in mortar, so it can be considered as a sustainable material for eco-friendly construction. This report could be useful as guidance and as a reference to the related organization and future research on clay and red soil based mortar

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REFERENCES

[1] Peter Duxson, John L. Provis, Grant C. Lukey , Seth W. Mallicoat , Waltraud M. Kriven , Jannie S.J. van Deventer "Understanding the relationship between geopolymer composition, microstructure and mechanical properties", Colloids and Surfaces A: Physicochem. Eng. Aspects 269 (2005) 47–58

[2] N A Lloyd and B V Rangan, "Geopolymer Concrete: A Review of Development and opportunities" 35thConference on Our World in Concrete & Structures: 25 - 27 August 2010, Singapore Article Online Id: 100035037

[3] C.D. Budh and N.R. Warhade "Effect of Molarity on Compressive Strength of Geopolymer Mortar" ISSN 2278-3652 Volume 5, Number 1 (2014), pp. 83-86

[4] S.K. Gupta, Mustakeem R. Khan, Nishant Nathani and Pragnya Prakash "Pedagogy for Green Building: India" ISSN 2249-3131 Volume 4, Number 1 (2014), pp. 27-32, http://www.ripublication.com/ijerd.htm

[5] Aaron Richard Sakulich, "Reinforced geopolymer composites for enhanced material greenness and durability"

[6] N A Lloyd and B V Rangan "Geopolymer Concrete with Fly Ash" ISBN 978-1-4507-1490-7 http://www.claisse.info/Proceedings.htm

[7] Tamil vanan.K: Modified Geopolymer mortar, May 2012.

[8] S. Steefna shiny: Durability of Geopolymer concrete, May 2005.

[9] HarekrushnaSutar, Subash Chandra Mishra, Santosh Kumar Sahoo, Ananta Prasad chakraverty and Himanshu Sekhar Maharana "Progress of Red Mud Utilization: An Overview" American Chemical Science Journal 4(3): 255-279, 2014

[10] J. A. PETER, M. NEELAMEGAM, J.K. DATTATREYA, N.P.RAJAMANE and S. GOPALAKRISHNAN, "Utilisation of flyash as cement replacement material to produce high performance concrete" 1999, NML, Jatnshedperr, pp. 38-49

[11] http://www.earth-auroville.com/ access on 25th March, 2015.

[12] http://www.ampri.res.in/ access on 13th April 2015.

[13] Radhakrishna, A Shashishankar and B C Udayashankar, "Phenomenological Model To Re-Proportion Geopolymer Compressed Blocks" 33rdConference on Our World in Concrete & Structures: 25 - 27 August 2008, Article Online Id: 100033036.

[14] Kolli Ramujee, "Development of Low Calcium Flyash Based Geopolymer Concrete" IACSIT International Journal of Engineering and Technology, Vol. 6, No. 1, February 2014

[15] A. Mohd Mustafa Al- Bakari, Omar. A.K.A.Abdul Kareem and San Myint "Optimization of Alkaline Activator/Fly Ash Ratio on the Compressive Strength of Fly Ash-Based Geopolymer"

[16] D.V. Reddy, J-B Edouard, K. Sobhan, A. Tipnis "Experimental Evaluation of the Durability of Fly Ash-Based Geopolymer Concrete in the Marine Environment" LACCEI'2011

[17] NIRAGI DAVE and VAISHALI SAHU "Experimental Evaluation of Low Calcium Fly Ash Based Geopolymer Concrete" ISSN: 0975-5462, Vol. 4 No.12 December 2012@IJEST

[18] http://theconstructor.org/buildings/ access on 14th March, 2015.

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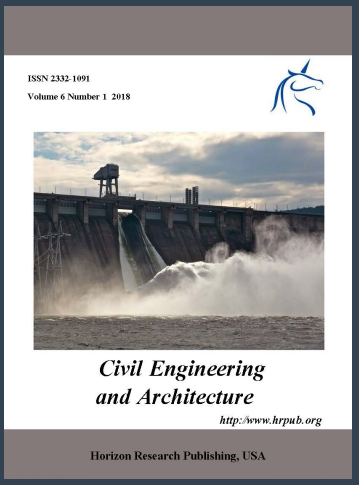

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