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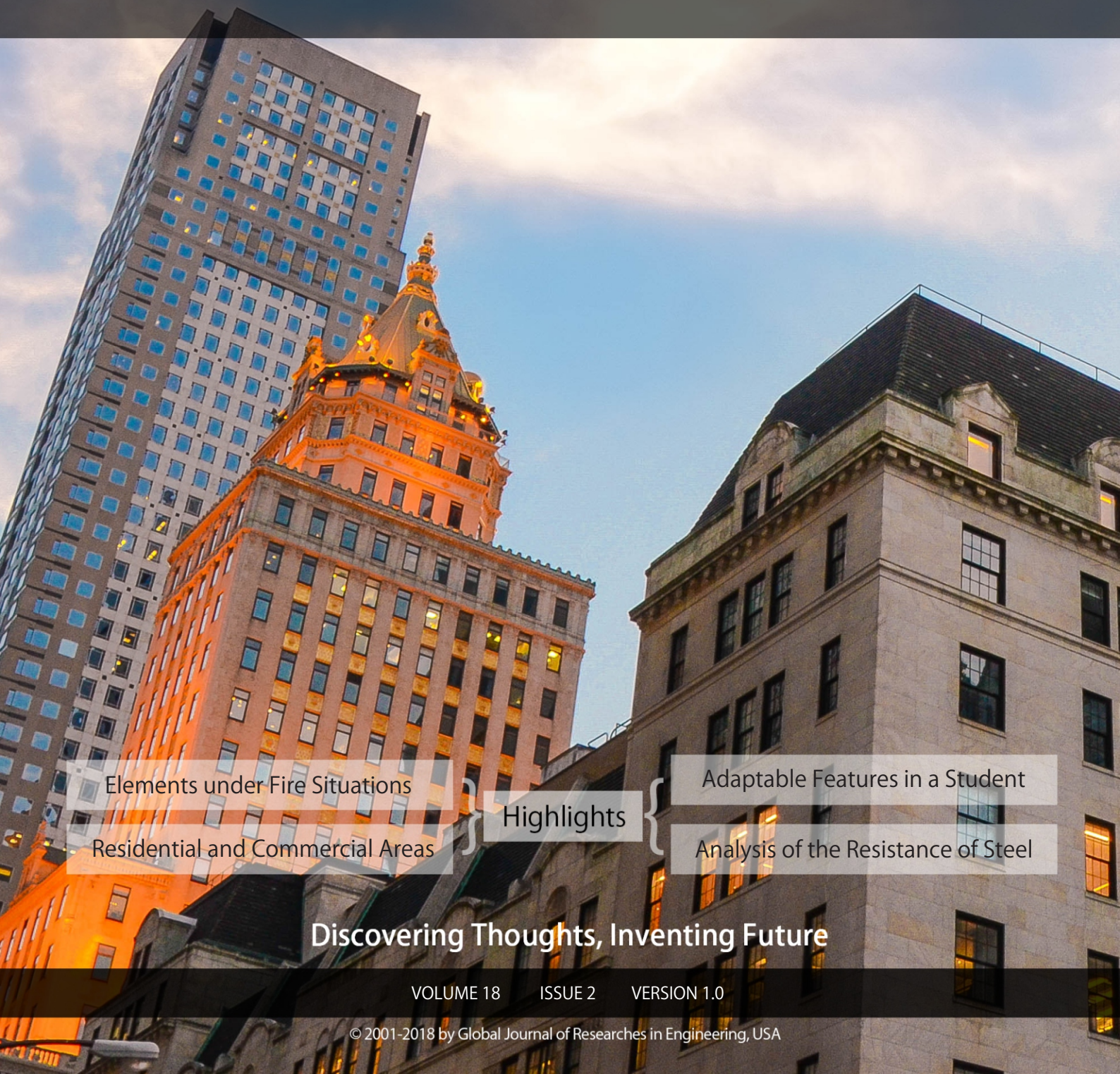

Highlights

- Elements under Fire Situations
- Residential and Commercial Areas
- Adaptable Features in a Student
- Analysis of the Resistance of Steel

Discovering Thoughts, Inventing Future

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Adaptable Features in a Student Accommodation: A Case Study from Malaysia

By Abdullah Abdul Rahim Chang & Muhammad Farooq

Abstract- One of the goals of this paper is to help understand adaptability in architecture. This includes various types of adaptability features, their importance and uses in terms of sustainability, economy and quality of life. Several interpretations of adaptability and flexibility from various researchers will be discussed, along with examples and case studies. However, the main aim of the paper is to discuss the needs of students and their desire and need for adaptability in their accommodation; focusing on the question that do students really need or use adaptable features when they want to stay for a short academic period in the accommodation. Based on the literature, we will see that adaptability has a lot to do with increasing the life of an accommodation in the sense that the inhabitants do not need to move to another house or apartment once their current accommodation is of no use to them. The adaptable accommodation will be able to 'adapt' to their ever-changing circumstances. However, the paper will focus very much on students, staying in a relatively adaptable accommodation and their response to the adaptable features offered to them. Do they even use these features as they are staying for only a short period?

Keywords: *adaptable architecture, adaptability, flexibility, student housing, quality of life, efficiency.*

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Adaptable Features in a Student Accommodation: A Case Study from Malaysia

Abdullah Abdul Rahim Chang[α] & Muhammad Farooq[σ]

Abstract- One of the goals of this paper is to help understand adaptability in architecture. This includes various types of adaptability features, their importance and uses in terms of sustainability, economy and quality of life. Several interpretations of adaptability and flexibility from various researchers will be discussed, along with examples and case studies. However, the main aim of the paper is to discuss the needs of students and their desire and need for adaptability in their accommodation; focusing on the question that do students really need or use adaptable features when they want to stay for a short academic period in the accommodation. Based on the literature, we will see that adaptability has a lot to do with increasing the life of an accommodation in the sense that the inhabitants do not need to move to another house or apartment once their current accommodation is of no use to them. The adaptable accommodation will be able to 'adapt' to their ever-changing circumstances. However, the paper will focus very much on students, staying in a relatively adaptable accommodation and their response to the adaptable features offered to them. Do they even use these features as they are staying for only a short period? Do these features help them in their daily lives and improve their quality of life? Research methodologies done in the paper include data collection from various literatures in order for a better understanding, interview with a professional and survey taken from students living in an adaptable accommodation in Cyberjaya, Malaysia.

Keywords: adaptable architecture, adaptability, flexibility, student housing, quality of life, efficiency.

I. Introduction

"If a building doesn't support change and reuse, you have only an illusion of sustainability." (Croxton, 2003)

When people build or buy a house, they either anticipate spending numerous years in it or a relatively shorter time. A typical house is designed to fulfill the general and basic needs of the majority. Once those needs are fulfilled, the tenants usually move out and look for another house that meets their changed needs. An example of this can be the elderly tenants. A childless, married couple can be living in a certain house for many decades. However, once they reach a specific age, their housing environment no longer provides them with physical comfort and support that they might need. Therefore, that house has lived out its time and the couple must move on to a different house. This act of searching, moving, selling and buying a different accommodation can be t edious, costly and difficult in terms of human emotions. What if this family never had to move in the first place? What if instead of them looking for a different house that met their needs, their existing house changed itself for their ever-changing requirements? This is the main idea of an adaptable house. It basically adapts effectively and efficiently to the ever-changing requirements and needs of the inhabitants, without any expensive and energy consuming alterations such as demolition, renovation or substantial modification to the existing structures and services. The city of Cyberjaya in Selangor, Malaysia, attracts numerous students globally due to the city being home to some of the most well-known universities in the country and abroad. These universities, such as Limkokwing University of Creative Technology and Multimedia University, brag about having multitude of students from all over the world. While many students play out their higher education phase in typically stable way, some students, especially from third world or war-torn countries suffer from financial issues.

For this purpose, flexible or adaptable housing can prove to be an excellent solution. Firstly, if designed well, the accommodation can be both aesthetic and functional, two things wanted and required by most foreign students. Secondly, the cost of rent will be reduced effectively as the long-term production and maintenance cost is lesser for an adaptable house/apartment than a rigid one. The factors of adaptability that will play a vital role will be such as students wanting to either share an existing unit with more students, friends, families, relatives etc. or wishing to turn a two-bedroom unit into a studio unit after the housemate leaves or graduates. Furthermore, the issue of oversupply of apartments/units can also be addressed by supplying adaptable apartments/units. They will also prevent the buildings from becoming obsolete over time as their functions will change as required, without needing extensive structural changes or demolition. Furthermore, according to a paper called 'Well-Being of UiTM Shah Alam Students Living in Off-Campus Environment' (Muslim, Abdul Karim, Abdullah, 2013), the housing development trends and fast-paced enrolments of students to universities currently are impacting the daily lives of students on the basis of comfort, safety and convenience. Relevant discussion will be carried out later in the paper.

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II. Literature Review

a) Housing Problems in Malaysia

According to a paper called 'Trends, Problems and Needs of Urban Housing in Malaysia' (Salfarina, A.G., Nor Malina M., Azrina, H.), housing is a huge problem for the billions in the bottom class. House and neighborhood conditions contribute greatly to an individual's quality of life. Findings from survey showed in the paper that some of the major concerns for home buyers are location and cost of the house (especially in urban areas). Majority of respondents felt that cost of urban houses in Malaysia was beyond their budget. After the independence from the British in the year 1957, the Malaysian Housing Policy, emphasis has forwarded from merely providing accessibility to housing, slums and overcrowding to housing with significantly better quality and affordability. In 1960, the focus was on increasing housing ownership. The notion of affordable housing as a basic human need was on the rise. This continued until the year 2000 but included new pieces of the New Economic Policy (NEP) objectives of restructuring salaries and assets between various ethnic groups, especially Malaysians, Chinese and Indians.

Majority of affordable housing has been provided by the local government under the public housing programs, even though both the public and private sectors also provide them. In 2011, the price of affordable houses is around RM 25k per unit, however, the cost varies depending on factors such as location, states, urban typologies etc. with targeted buyers of RM 750 per month income (S. Abdul Ghani, and L. M. Lee, 1997). Current housing policies have changed its emphasis from low cost housing to meet the requirements of the middle-income groups, especially the lower middle class. The researchers concluded the paper by discussing the results of their research. Their findings proved that the house purchasing in urban Malaysia is determined by age, education level, gender and income. Findings also showed that some of the main concerns for the buyers were the location and cost of housing, with most stating that the prices were beyond their budget. Other than that, location and distance from work place was also considered as one of the major concerns. However, when it came to satisfaction in terms of sociocultural and religious facilities in the housing area, the respondents seemed quite satisfied with majority of them not taking ethnic diversity as an issue in decision making when purchasing houses.

b) Historic Background of adaptable architecture

Even though the term 'adaptable housing' has started to be interpreted in new ways, it is no longer a new and unique idea. Schneider & Till suggest two scenarios for the development of flexible housing in history. The first indicates that development came as a result of evolving conditions in vernacular housing (Schneider & Till, 2012). Vernacular architecture tends to be very adaptable. Usually constructed by hand using local materials, structures can be easily added on to or demolished and recycled naturally. Although adaptability in the form of the vernacular is not exactly applicable to contemporary modern architecture, vernacular architecture offers many ways that a building might naturally evolve over time and expanding to fit its occupants, reducing or gaining layers through different seasons, etc. The second scenario developed in response to external pressures that have prompted designers to create alternative design solutions. This is the contemporary version of adaptability involving architects and other experts. Schneider & Till propose three key drivers in the development of contemporary adaptable housing.

The first phase came about in the 1920's (following the First World War) in response to the need for European social housing programs to provide mass housing for the working class. In order to supply housing to as much of the population as possible, smaller space standards were adopted. Schneider & Till term this phase "modernity and the minimal dwelling," arguing that early modernist architects sought to make these minimal dwellings as functional as possible using elements of adaptable design. Dutch architects such as Johannes van den Broek experimented with changeability of use and it was concluded that due to some rooms went unused for much of the day, these spaces should afford different uses during that time. For example, a bed could fold up to provide additional living room or office space during the day. In the Schröder Huis, designed by Gerrit Rietveld, a complex system of sliding walls and folding screens adapted to suit the daily cycles of the family. The second phase in the evolution of adaptable housing began in the 1930's and was essentially based around the belief that flexible housing could be available to all by means of prefabrication and other emerging technologies.

The third phase began in the 1960's, when the move towards participation and user involvement led to a new interest in adaptable housing as a means of providing user choice. John Habraken recommended the idea of the building of "supports", which consists of the primary structure, the building envelope, circulation spaces, and mechanical systems. These supports can then be in filled by occupants in a systematic order to accommodate a variety of floor plans and features (Habraken, 1972). Since the era of Supports, Habraken's ideas for residential open building practices are being adopted for use more frequently, especially in Finland, Japan and the Netherlands (Kendall, 2011).The aim of this literature review is to discuss various opinions and methodologies on the following matters:Various definitions and meanings of adaptability (in context of student accommodation); Effects of adaptability on

student's economy, quality of life and satisfaction; Valuable adaptable features to students in their accommodations. Because of evolution in digitalization (Farooq *et al.*, 2018) customers want quality services (Buzdar, 2014; Buzdar, Janjua and Khurshid, 2016) and this applied to all housing related customers.

III. Research Methodology

Many international students travel to Malaysia for higher education and stay in the country for only a certain period of time (depending on the duration of their desired course). From the literature given in this paper, we can see that the notion of adaptability in housing makes it abundantly clear that it aims to prevent unnecessary changing of home whenever any new circumstance in life occurs. The idea is that the house itself must adapt to the changing needs of the inhabitants rather than the inhabitants changing their accommodation to meet their newer requirements. From this, we can arrive at the conclusion that it would make more sense if adaptable features in an accommodation are targeted for residents who are planning to stay in that accommodation for a long period of time.

The aim of this research is to look into this matter from students' perspective and to find out whether students (both national and international) require a certain level of adaptability in their student housing or not. As mentioned before, the uniqueness of this matter resides in the fact that most students plan to stay in a student accommodation for the duration of their study period (short term stay) and to find out whether they require adaptive features in their accommodation (which is usually a long-term approach). This paper tried to find the relationship between these two extremes i.e. short term staying of students in an adaptable accommodation.

The research was carried out through data collection and the outcome was compared to various literatures on the topics of student housing and adaptable housing. The data collection was done via questionnaire and an interview. The interview was conducted with an architect, whereas the survey through questionnaire targeted only students living in a chosen adaptable accommodation. Graphs were created to assist in evaluating the survey results in a statistical manner. The site chosen for the research was the Garden Plaza complex located in Cyberjaya, Selangor. The apartment units offer a small level of flexibility and adaptability to the occupants. Also, it is very close to Limkokwing University of Creative Technology, making it popular amongst students of the university to live in.

IV. Summary and Analysis of Interview

Society may be reluctant to the idea of adaptability in housing if its cultural and religious beliefs are subject to compromise, even if it results in inefficient use of spaces. Adaptability in housing can be very useful as many people do not plan for later when buying a house. They might not have decided on how many children they will have or whether the idea of divorce of a married couple is on the table (such things are of course difficult to predict). However, based on the response from the interview, adaptability can be a useful solution to combat these unpredictability's in a convenient and efficient manner without needing to make drastic changes such as moving out of the house in search of a better suited one etc. This point is in line with the paper 'Towards Specific Adaptable Housing' (as mentioned in the literature review). Adaptability is one of the solutions to the housing problems but cannot be selected as the main solution. There are simply too many variables to consider and all the issues cannot be solved with just one method. The example of military base in Dhahran Eastern Province can be related to 'the Next Home' project mentioned earlier. The military based used a similar method of cataloging components separately and making use of only those components that are needed at a time, preventing waste and thus, resulting in cost and energy efficiency. Adaptable features may appeal to bachelors rather than families, as families are restricted by cultural and traditional norms.

V. Survey Results and Discussion

53% of respondents occupied 3-bedroom units, 20% occupied 4-bedroom units and 27% occupied single bedroom studios, making a total of 73% of the respondents living with housemates and 27% living solo. The reasons of this are most likely financial, as the single bedroom studio is the most expensive for a single student whereas in multi-bedroom units, the rent is shared evenly and the individual costs are lowered. This also tells us that the students are willing to compromise privacy for the sake of finance, as the interior walls are not of full height and therefore, the units are lacking sound privacy 35% of the respondents are highly satisfied with the adaptable features, 52% are with a medium satisfaction level, making a total of 87% of happy and satisfied occupants. This number shows that the majority of these students are happy with the adaptable features. This fact can be related to the 5th pie chart, which showed that the overall majority of the respondents (87%) will be staying for not more than 2 years, whereas only a minority of 13% will stay from 3 to 4 or more years. This shows that out of all the respondents, 87% were happy with the adaptable features and also, 87% were staying for a short-term period (i.e. not more than 2 years).This result answers the third research question; almost 90% of the surveyed students, living in the adaptable accommodation for a short period, do utilize the adaptable features given to them and in fact, want more features as per pie chart 4,

where the majority wished for higher adaptability levels in the units.

60% of the students receive not more than RM 2000 allowance per month and 75% of them are undertaking Bachelor degree level courses, which is a full-time course for majority of universities in Malaysia (as supported by a website called www. Bachelor studies.com where only two universities are shown to offer part-time bachelors programs in the country). This means that majority of the students surveyed receive allowance that can be classified as middle-class income. This is based on the website called www.quora.com that classifies middle income class's starting salary for graduated employees to be RM 2000 (Rashid Mohamed, 2015). Furthermore, based on graphs from answer 6, 26 out of 40 respondents rated the rent as either 'Excellent' or 'Good'. These statistics prove that majority of the students are able to live in the Garden Plaza, a relatively adaptable accommodation, with mid-class income.

We saw that majority of respondents (40%) found the given adaptable features to be very useful in case an extra member wants to stay over or move into the unit, whereas 35% believed that the features would provide medium level of usefulness. This shows that 75% of the respondents found the features to come in handy when a new member wants to join the unit. As mentioned earlier in the description of Garden Plaza, many rooms have features or situations where the air conditioners and televisions can be shared between rooms (due to revolving wall partitions and partition walls that are not of full ceiling height). This can conclude that students are allowed to tailor scenarios where they can cut costs by compromising on some factors. This conclusion answers the first research question; adaptable features offered in the Garden Plaza can have a positive impact on the occupant's financial situation, however, it depends on how the adaptable features are utilized by the occupants.

Majority of the respondents can be seen to rate factors that can determine a student occupant's well-being such as 'flexible layout', 'neighborhood', 'security', 'unit size' and 'rent' as 'Good'. This shows that all of those students living in Garden Plaza were fairly happy with these factors and thus, willing to continue staying there for their academic period. In a way, this data complies with the survey from the paper 'Room and board Redefined: Trends in Residence Halls' (www.hermanmiller.com, 2007) mentioned in the literature review, in the sense that both data show similarity in student's importance to residential facilities. The results from with another paper called 'Well-Being of UiTM Shah Alam Students Living in Off-Campus Environment' (Muslim, Abdul Karim, Abdullah 2013), where It was found that 'living conditions' was the second highest off-campus environment area mentioned by students, thus, showing that comfort is an important factor. Based on the analysis of the survey results, we have the answer to the second research question; the quality of student's life can be improved if sufficient, relevant and useful adaptable features are provided to the students, along with cost efficient solutions.

VI. Conclusion

The results from the survey can be seen to go against the usual notion of adaptability; that it serves as an important feature for occupants who wish to inhabit an accommodation for life. This paper, based on user-preference, has proven that students staying for a short-term duration, for the sole purpose to fulfill their higher educational period, do appreciate and utilize the adaptable features when offered as a part of their accommodation. This changes the way we think about adaptability in any sort of accommodation. It is not merely a tool to increase the life of a building or 'recycle' the functionality of a given space in various ways but can also be used as an efficient tool to for those who wish to stay in an adaptable accommodation for a short period of time. For students who struggle financially and otherwise, it can prove to be an important asset in their daily lives, as adaptable features do allow them to have a controlled level of flexibility that they can manipulate based on their requirements.

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Analysis of the Resistance of Steel Elements under Fire Situations: A Comparative Study between Standard ABNT NBR 14323: 2013 and its 1999 Version

By Luciano Lins, Ramon Silva, Emanuella Guntzel & Luciano Bezerra

Abstract- The structural elements of steel when subjected to the action of a fire suffer degeneration of their physical and chemical characteristics as a consequence of the high thermal effect, decreasing their resistance and rigidity, and causing alterations in the conditions of the initial state of the structure's tensions and deformations. The stability guarantee of a structural element of steel under the action of a fire is provided by handling time, temperature and resistance. The sizing criteria are established as a function of the temperature curves versus time, which allows the possibility to calculate the effect of thermal action on the structural elements. The objective of this work is to compare the simplified sizing methods for the calculation of the traction of bars under the effect of high thermal gradients as proposed by ABNT NBR 14323: 1999 and the one presented in the most recent version of this guideline, published in 2013.

Keywords: thermo-structural analysis, metal structures, fire, sistematical analysis and dimensioning.

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Analysis of the Resistance of Steel Elements under Fire Situations: A Comparative Study between Standard ABNT NBR 14323: 2013 and its 1999 Version

Luciano Lins [α], Ramon Silva [σ], Emanuella Guntzel [ρ] & Luciano Bezerra [ω]

Abstract- The structural elements of steel when subjected to the action of a fire suffer degeneration of their physical and chemical characteristics as a consequence of the high thermal effect, decreasing their resistance and rigidity, and causing alterations in the conditions of the initial state of the structure's tensions and deformations. The stability guarantee of a structural element of steel under the action of a fire is provided by handling time, temperature and resistance. The sizing criteria are established as a function of the temperature curves versus time, which allows the possibility to calculate the effect of thermal action on the structural elements. The objective of this work is to compare the simplified sizing methods for the calculation of the traction of bars under the effect of high thermal gradients as proposed by ABNT NBR 14323: 1999 and the one presented in the most recent version of this guideline, published in 2013. The results indicated that the latest standard is less conservative. In Brazil, the studies related to effects of a fire in structures have been increasing; however, there is still much to be done, such as the real-scale simulation of the behavior of a fire in a compartment.

Keywords: thermo-structural analysis, metal structures, fire, sistematical analysis and dimensioning.

I. Introduction

During the occurrence of the phenomenon of fire in a compartment, the analysis of the resistance of the steel structures can be performed by measuring conditions that the structure is submitted to in room temperature, combined with the simultaneous effect of high thermal gradients of a fire, thus designing buildings capable of withstanding the demands of such a situation. (Rigobello, 2011).

Components of the structure. Therefore, it is not taken into account the interaction between those elements during the heat propagation phase in the structure. (Kirchh of, 2004).

Fire safety engineering procedures are based on complex analysis when compared to the same phenomenon at room temperature. It should be considered that the behavior of the fire can change depending on the situation in such a way that its effects are attenuated and cannot be discarded during the design phase of the building. (Rigobello, 2011).

The results of the systematical analysis will be fundamental to evaluate the technological development in the field of research on steel structures under a fire situation, thus making it possible to stimulate the technical adoption of measures to protect the structures in an efficient, economical and simplified way.

II. Safety Check under A Fire Situation

When submitted to high thermal gradients due to a fire, the steel structures gradually suffer resistance and rigidity decreases, as well as changes in the conditions observed on their initial state of equilibrium, creating tensions and structural deformations. (Silva,1997).

The guarantee of the stability of a structural steel element under the action of fire is verified by handling the variables of time, temperature and resistance.

According to Mesquita (2013), in the temporal sphere the structure must be designed to withstand without collapsing during a period that allows the safe escape of the users and the safety of firefighting teams. In Brazilian standards and regulations, it is related to the Required Time of Resistance to Fire. It is represented by Equation 1

$$t_{f,d} > t_{f,req} \quad (1)$$

Where:

$t_{f,req}$ - is the required time of resistance to fire;

$t_{f,d}$- is the calculation value of fire resistance based on standart fire ISO 834.

In order for the structural steel element avoid collapsing during the thermal action, its temperature

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must be below the critical temperature. This criterion is called verification in the temperature domain. In addition, according to Silva (2001), the safety of the structures is met in a fire situation when the temperature affecting the steel structural elements is lower than the temperature that promotes structural collapse, that is, the critical temperature.

The Equation #2 represents the structural safety check by the temperature degree analysis.
Where:

$$\theta_a \leq \theta_{cr} \quad (2)$$

θ_a - is the temperature of the steel;
θ_{cr} - is the critical temperature.

For the calculations concerning the resistance sphere, it must be taken into account the simultaneous effect of the actions that the structure is subjected to at room temperature, along with the exceptional actions (fire action). Based on this accidental combination, it is possible to calculate the resistance capacity of the structural elements, which should be lower than the calculation of the request in a fire situation (Mesquita, 2013).

$$R_{fi,d} \geq S_{fi,d} \quad (3)$$

$S_{fi,d}$ - is the requesting effort of calculation in situation of fire, obtained from the combination of actions;

$R_{fi,d}$ - is the corresponding resistance effort of the structural element to the maximum limit state under consideration in a fire situation.

III. Methodology

The analytical model addressed in this study refers to the simplified sizing method, proposed by NBR 14323: 2013 for the determination of the thermal action that reaches the structure during the occurrence of a fire in a building. With this tool, it is possible to calculate the thermal gradient by means of the flux of radiation and convection emanating from the flames.

The simplified sizing method is applied to the structural elements engulfed by the hot gases, caused by the occurrence of a fire inside a compartment. It can be also applied in safety analysis of elements external to the building, but this will not be addressed in this study (Silva, 2001).

Without dismissing the deformations caused by thermal effects, the resistance analysis will be carried out so that the modulus of elasticity of the steel and its respective flow limit is constant and with its value adopted at elevated temperature (NBR 14323: 1999). The purpose of this analysis is to determine the ultimate load of the structural strength of steel.

In order to obtain the values of the resistant capacity of the structural steel elements through this method, it is necessary to take into account that the thermal analysis used is the stationary type, that is, the distribution of temperature and other thermal quantities along the cross section and the length of the steel element shall be considered uniform (Rodrigues, 2013).

For those cases in which safety engineering adopts the standard fire, the same expressions of this method can be employed, considering the effects of a variable temperature distribution through factors such as outflow resistance reduction and the modulus of elasticity corresponding to the highest temperature reached by the element during the action of the thermal gradient. (NBR 14323: 2013).

The calculation methodology discussed in this paper will follow the calculation procedures established by Silva (2001). However, it will be readapted to the new formulation proposed by NBR 14323: 2013. In this sense, it will continue with the determination of the resistance efforts of the structural elements in the traction, comparing it with the results obtained in the previous version of the norm in 1999.

According to Silva (2001), the analytical simulations that will be presented in this study were performed with the following simplifying assumptions:

- The structural element is fully immersed in the burning environment;
- The distribution of temperature in the structural element is uniform;
- There is an one-dimensional heat flux in the structural element;
- It is recommended to consider $\Delta_t < 5s$.

IV. Determination of Temperature in the Structural Element

For a more sophisticated analysis of the behavior of the steel piece subjected to the high heat exchanges caused by fire action, it is necessary to understand how the temperature distribution is carried out along its cross section through the analysis of heat transfer (Campêlo, 2008).

When the phenomenon of fire occurs in an environment, the temperature of the structural elements after a time interval tends to approach the temperature of the hot gases (Kimura, 2009). This temperature inequality generates a thermal action, characterized by a heat flux which is transferred to the structure by radiation and convection, causing a rise in temperature in the structural element (Silva, 2001).

Radiation is defined as the process in which heat does not need a physical medium to propagate. It flows in the form of waves from one body at elevated temperatures to the surface of another with lower temperature (Dorr, 2010).

Convection concerns the transfer of heat through the movement of fluids, gases or liquids. When the heat transfer occurs through the convective flow, the flame propagation is analyzed by the movement of the smoke and by the presence of the hot gases in the

ceiling or out of the burning compartment (Azevedo, 2010).

The main mechanisms of thermal analysis of a structural element subject to the action of a fire are: test results, simplified models, and advanced or computational models (Rigobello, 2011). It is possible to determine the temperature increase by considering the thermal equilibrium between the heat coming from the fire and the heat absorbed by the steel profile (Campêlo, 2008).

V. Mass Factor

The temperature that the structure reaches during a fire is strongly influenced by the relationship between the surface area exposed to heat and the mass of the profile. This relationship is called a mass factor (Bellei, 2008).

For prismatic bars, the mass factor can be expressed by the relation between the perimeter exposed to the fire (u) and the area of the cross section of the bar, also known as the form factor of the section (Silva, 2001).

Regarding the structural elements of steel without thermal protection subject to fire action, the mass factor can be expressed by equation 4.

$$u/A_g \quad (4)$$

Where

u- is the perimeter of the steel structural element, exposed to fire;

A_g- is the cross-sectional area of the structural steel element.

It is possible to deduce that concerning elements with the same area, those that have less exposure to the fire will have a slower heating when compared to the other elements. And for the elements with the same exposed surface to the fire, the one that has greater mass will experience a slower heating as well. (Rodrigues, 2013)

Therefore, the lower the mass factor of a structural element is, the greater is its resistance to the various temperatures it undergoes (Bellei, 2008).

VI. Element Without Thermal Protection

a) Generality

NBR 14323: 2013 establishes that for an uniform temperature distribution along the cross section, the temperature rise,$\Delta\theta_{a,t}$, of a structural steel element uncoated against the fire inside of a building, over a period of time, can be determined by means of equation 5.

$$\Delta\theta_{a,t} = k_{s,h}\frac{(u/A_g)}{\rho_a c_a}\varphi\Delta_t \quad (5)$$

Where:

$\Delta\theta_{a,t}$- is the temperature change in a steel structural element, during a time period**Δt;**

$k_{s,h}$- is a correction factor for the shading effect, which can be taken equal to 1.0 or determined as we will see later;

u/A_g-is the mass factor for structural steel elements with no protection against fire, expressed in meters at a minus one (m-1);

ρ_a- is the specific mass of the steel, expressed in kilograms per cubic meter (kg/m^3);

c_a- is the specific heat of the steel, expressed in joules per kilogram and by degrees Celsius (J / kg ° C);

φ- is the value of the heat flux per unit area, expressed in watts per square meter (w/m^2);

Δ_t- is the time period, expressed in seconds.

b) Shading effect

The shading effect is characterized by the fact that it acts on concave shaped profiles in cross sections H or I. It is caused by local obstructions of the thermal radiation due to the shape of the steel profile, as shown in figure 1 (Rigobello, 2011).

The shading factor for the I or H profiles, subject to the thermal action of a standard fire, is represented by equation 6:

$$k_{sh} = 0{,}9\frac{(u/A_g)_b}{(u/A_g)} \quad (6)$$

Where:

$(u/A_g)_b$- is the value of the mass factor, defined as the ratio between the perimeter exposed to the fire of a hypothetical box that surrounds the profile and cross-sectional area of the profile;

(u/A_g)- is the mass factor for structural steel elements with no protection against fire.

For closed cross-sections such as the coffin and tubular, circular and rectangular sections, and solid ones as the rectangular sections, all fully exposed to fire, the value of k_sh = 1, according to Figure 1.

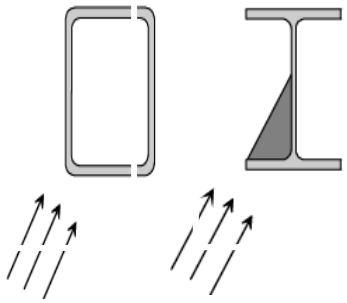


Figure 1: Shading effect: a) Open section; b) Closed section

c) Calculation Methodology

Silva (2001) presents a calculation script for the determination of temperature action on the structural element, through the action of a standard fire. The

procedure was adapted to the calculation established by NBR 14323: 2013, as follows.

Consider:

$$\theta_a(t=0) = 20℃ \quad (7)$$

Where:

$\theta_a(t=0)$- is the temperature of the steel at room temperature.

If $t = 5s$.

The heat flux due to radiation is determined:

$$\varphi_r(t) = 5{,}67x10^{-8}\varepsilon_{res}\left[(\theta_g(t)+273)^4 - (\theta_a(t-\Delta_t)+273)^4\right] \quad (9)$$

If $\Delta_t = 5/60$ min and $\varepsilon_{res} = 0{,}7$.

Where:

φ_r- is the component of the heat flux due to radiation;

ε_{res}- is the resulting emissivity;

$\theta_g(t)$- is the temperature of the gases at time t;

$\theta_a(t-\Delta_t)$- is the temperature of the steel at time t - Δt.

The heat flux due to convection is determined:

Where:

α_c- is the coefficient of heat transfer by convection, taken equal to 25 W / m².

The heat flux is determined:

$$\varphi = \varphi_c + \varphi_r \quad (11)$$

Where:

φ– is the value of the heat flux per unit area;

The temperature variation of the steel $\Delta\theta_{a,t}$.

$$\Delta\theta_{a,t} = k_{sh}\frac{(u/A_g)}{\rho_a c_a}\varphi\Delta_t \quad (12)$$

It is determined the value of the temperature of the steel:

$$\theta_a(t) = \theta_a(t-\Delta t) + \Delta\theta \quad (13)$$

We return to item c, with t + Δt, instead of t.

Figure 2 shows the influence of the mass factor in determining the temperature of the structural element.

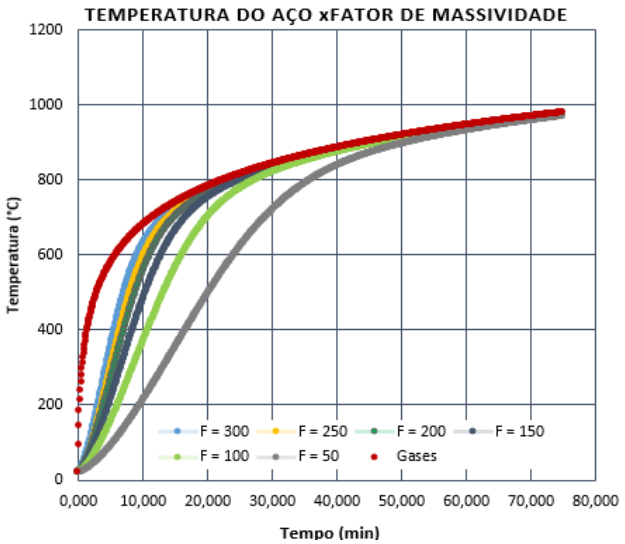


Figure 2: Steel temperature as a function of the mass factor

The temperature of the gases is determined:

$$\theta_g(t) = 345\log(8t+1) + 20 \quad (8)$$

Where:

$\theta_g(t)$- is the temperature of the gases at time t;

t - is the time in minutes.

VII. Resistance Calculation

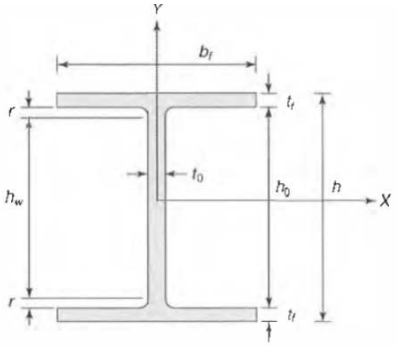
A W 150x37.1 profile in MR250 steel is subjected to an axial tensile load Nfi, sd = 200 kN. Assuming that the member is subject to an ISO 834 standard fire action, determine the element resistance after 30 minutes of exposure. Consider that in the first case the four sides of the structural element are exposed to the flames and in the second case there is the exposure of only three of its sides. Make sure that the profile has the minimum conditions for temperature and resistance evaluations.

Assuming that the element has all four sides exposed, according to NBR 14323: 2013 we will have:

$$\theta_g = 345\log(8*30+1) + 20 = 842℃ \quad (14)$$

Determination of the temperature of the gases:

The mass factor is then calculated according to the characteristics of the profile, as follows in Chart1.



Perfil	Massa	Alt.	Área	Alma		Mesa		Eixo X-X				Eixo Y-Y				J		
I	m	h	A	t_0	h_0	t_f	b_f	I_x	W_x	i_x	Z_x	I_y	W_y	i_y	Z_y		$b_f/2t_f$	h_w/t_0
	kg/m	mm	cm²	mm	mm	mm	mm	cm⁴	cm³	cm	cm³	cm⁴	cm³	cm	cm³	cm⁴		
W 150 × 37,1	37,1	162	47,8	8,1	139	11,6	154	2244	277,0	6,85	313,5	707	91,8	3,84	140,4	20,6	6,6	14,7

Chart 1: Perfil W 150 X 37, 1

$$k_{sh} = 0{,}9\frac{(u/A_g)_b}{(u/A_g)_b}$$

$$\left(\frac{u}{A_g}\right) = \frac{2d + 4f - 2t_0}{A_g} = \frac{2.16{,}2 + 4.15{,}4 - 2.0{,}81}{47{,}8}.100 = 193{,}26\ (m^{-1})$$

$$\left(\frac{u}{A_g}\right)_b = \frac{2(b+h)}{47{,}8} = \frac{2(15{,}4 + 16{,}2)}{47{,}8}.100 = 131{,}67\ (m^{-1})$$

$$k_{sh} = 0{,}9\frac{\left(\frac{u}{A_g}\right)}{\left(\frac{u}{A_g}\right)} = k_{sh} = 0{,}9\frac{131{,}67}{193{,}26} = 0{,}632$$

Then: $k_{sh}.\left(\frac{u}{A_g}\right) = 0{,}6132.193{,}26 = 118{,}34\ (m^{-1})$

Then, the model of Franssen and Real (2012) is used to determine the temperature of the steel devoid of thermal rotection, exposed 30 minutes to the fire ISO 834, at time t - Δt, according to Chart 2:

Temperature of unprotected steel in °C, exposed to the ISO 834 fire curve for different values of $k_{sh}\frac{A_m}{V}$, $[m^{-1}]$ (continued)

Time [min.]	10 m^{-1}	15 m^{-1}	20 m^{-1}	25 m^{-1}	30 m^{-1}	40 m^{-1}	60 m^{-1}	100 m^{-1}	200 m^{-1}	300 m^{-1}	400 m^{-1}
24	197	271	337	396	448	532	641	726	767	791	799
25	207	284	353	414	467	552	658	732	780	801	807
26	217	298	369	432	485	570	674	735	792	809	813
27	227	311	385	449	503	588	688	739	803	816	820
28	237	324	401	466	521	604	701	746	813	823	826
29	247	338	416	482	538	621	712	756	821	829	831
30	257	351	431	498	554	636	721	767	828	835	837

Chart 2: Steel Temperature Unprotected, Exposed to Fire ISO 834 Standard

You're for the intermediate values of$\theta_a(t - \Delta t)$ it is necessary to interpolate. In the case of this study the determined value was$\theta_a(t - \Delta t) = 777{,}34$°C.

The radioactive flux is determined by:$\varphi_r(t) = 5{,}67x10^{-8}\varepsilon_{res}[(\theta_g(t) + 273)^4 - (\theta_a(t - \Delta t) + 273)^4]$

$$\varphi_r(t) = 5{,}67x10^{-8}.0{,}7[(842 + 273)^4 - (777{,}34 + 273)^4 = 13039{,}24\ (W/m^2)$$

The convection heat flux is determined by:

$$\varphi_c(t) = \alpha_c\left(\theta_g(t) - \theta_a(t - \Delta t)\right)$$

$$\varphi_{c(t)} = 25(842 - 777{,}34) = 1615{,}5\ (W/m^2)$$

Determination of total flow:

$$\varphi = \varphi_r + \varphi_c$$

$$\varphi = 13039{,}24 + 1615{,}5 = 14654{,}74\ (W/m^2)$$

Determination of the increase of the steel temperature:

$$\Delta\theta_a = k_{sh}\frac{(\frac{U}{A_g})}{\rho_a C_a}\varphi\Delta_t$$

$$\Delta\theta_a = \frac{118{,}34}{7850.600}14654{,}74.5 = 1{,}84°C$$

Thus:

$$\Delta\theta_a = \theta_a - \theta_a(t - \Delta t)$$

$$\theta_a = \Delta\theta_a + \theta_a(t - \Delta t)$$

$$\theta_a = 1{,}84 + 777{,}34$$

$$\theta_a = 779{,}18°C$$

The next step is to determine the factor of resistance reduction to the flow of the profile at a high temperature. Therefore, the reduction coefficients adopted by NBR 14323: 2013 are used, as demonstrated by Chart 3.

Temperature of Steel θ_a °C	Factors of reduction of the Resistance to the drainage Ky,θ	Factors of reduction of elasticity module [a] KE,θ
20	1,000	1,000
100	1,000	1,000
200	1,000	0,900
300	1,000	0,800
400	1,000	0,700
500	0,780	0,600
600	0,470	0,310
700	0,230	0,130
800	0,110	0,090
900	0,060	0,068
1000	0,040	0.045
1100	0,020	0,023
1200	0,000	0,000
To intermediary Values of the temperature of Steel, can be done linear interpolation		

Chart 3: Factor of reduction of the resistance to the drainage x temperature of the steel

By interpolation, the value of the resistance reduction factor in the flow is obtained $K_{y,\theta} = 0{,}1350$. For traction the calculation resistance is:

$$N_{fi,Rd} = A_g K_{y,\theta} f_y = 47{,}8.0{,}1350.25 = 161{,}325kN$$

Verifications

Temperature Domain

$$\theta_{cr} = 39{,}19 \ln\left(\frac{1}{0{,}9674.\,K_{y,\theta}{}^{3{,}833}} - 1\right) + 842 < \theta_a$$

$$\theta_{cr} = 39{,}19 \ln\left(\frac{1}{0{,}9674.\,0{,}1350^{3{,}833}} - 1\right) + 482 < 787{,}767$$

$$\theta_{cr} = 784{,}084 < 787{,}767℃$$

(Checks)

Resistance Domain

$$R_{fi,Rd} \geq S_{fi,Rd}$$

$$161{,}325(kN) \leq 200(kN)$$

(Does not check)

Chart 4 presents a summary of the calculations for determining the strength of the profile, assuming that the steel element without thermal protection has 3 of its sides exposed. According to NBR 14323: 2013, the results are:

$\left(\frac{u}{A_g}\right)$ (m^{-1})	$\left(\frac{u}{A_g}\right)_h$ (m^{-1})	$k_{sh}\left(\frac{u}{A_g}\right)$ (m^{-1})	$\theta_a(t-\Delta_t)$ (°C)	φ_r (W/m^2)	φ_c (W/m^2)	φ (W/m^2)	$\Delta\theta_a$ (°C)	θ_a (°C)	$R_{fi,Rd}$ KN
161,05	132,21	118,19	785,08	11599,55	1423	13022,55	1,634	786,714	114,03

Chart 4: Determination of the strength of the structural steel element, as NBR 14323:2013

Verifications:

Temperature Domain

$$\theta_{cr} = 39{,}19\, ln\left(\frac{1}{0{,}9674.\,K_{y,\theta}{}^{3{,}833}} - 1\right) + 482 < \theta_a$$

$$\theta_{cr} = 39{,}19\, ln\left(\frac{1}{0{,}9674.\,0{,}1226^{3{,}833}} - 1\right) + 48786{,}71$$

$$\theta_{cr} = 784{,}084 < 787{,}767℃$$

(Does not check)

Resistance Domain

$$R_{fi,Rd} \geq S_{fi,Rd}\, 151{,}287\ (kN) \leq 200(kN)$$

(Does not reist)

Assuming that the element has all four sides exposed, according to NBR 14323: 1999 we will have: The temperature of the gases: $\theta_g = 345\, log(8 * 30 + 1) + 20 = 842℃$The mass factor according to the characteristics of the profile shown in figure 4 is obtained as follows:

$$\left(\frac{u}{A_g}\right) = \frac{2d+4f-2t_0}{A_g} = \frac{2.16{,}2+4.15{,}4-2.0{,}81}{47{,}8}.100193{,}26\ (m^{-1})$$

Then, the model of Franssen and Real (2012) is used to determine the temperature of the steel devoid of thermal protection, exposed 30 minutes to the fire ISO 834, at time t - Δt, as presented in Chart 2. However, for this version of the 1999 standard it was not taken into account the effect of shading, that is, $k_{sh} = 1$.

Thus, for the intermediate values of $\theta_a(t-\Delta t)$, it is necessary to interpolate. In this study the determined value was $\theta_a(t-\Delta t) = 823{,}28$℃.Then, the radioactive flow of heat is determined:

$$\varphi_r(t) = 5{,}67x10^{-8}\varepsilon_{res}[(\theta_g(t)+273)^4 - (\theta_a(t-\Delta t)+273)^4]$$

$$\varphi_r(t) = 5{,}67x10^{-8}.0{,}5[(842+273)^4 -$$

$$(823{,}28+273)^4] = 2869{,}40\ (W/m^2)$$

The following is the heat flow by convection: $\varphi_c(t) = \alpha_c\left(\theta_g(t) - \theta_a(t-\Delta t)\right)$

$$\varphi_c(t) = 25(842-823{,}28) = 468\ \left(\frac{W}{m^2}\right)$$

The total heat flux, which reaches the structural steel element, is then calculated

$$\varphi = \varphi_r + \varphi_c$$

$$\varphi = 2869{,}40 + 468 = 3337{,}4\ (W/m^2)$$

Then, the temperature increase of the steel is determined by:

$$\Delta\theta_a = \frac{(U/A_g)}{\rho_a C_a}\varphi\Delta t$$

$$\Delta\theta_a = \frac{193{,}26}{7850\ 600}3337{,}4.5 = 0{,}6847℃$$

Thus:

$$\Delta\theta_a = \theta_a - \theta_a(t-\Delta t)$$

$$\theta_a = \Delta\theta_a + \theta_a(t-\Delta t)$$

$$\theta_a = 0{,}6847 + 823{,}28$$

$$\theta_a = 823{,}96℃$$

Then, the flow limit reduction factor is determined for the calculation of the tensile strength of the structural element in a fire situation. For this, Chart 3 is used observing that there was no change in the respective values of the coefficients in the update from one norm to another.

By interpolation, the value of $K_{y,\theta} = 0{,}09802$.

For traction, the calculation resistance is:

$$N_{fi,Rd} = A_g K_{y,\theta} f_y = 47{,}8.0{,}09802.25 = 117{,}13\ kN$$

Verifications

Temperature Domain

$$\theta_{cr} = 39{,}19\ln\left(\frac{1}{0{,}9674.K_{y,\theta}{}^{3{,}833}} - 1\right) + 482 < \theta_a$$

$$\theta_{cr} = 39{,}19\ln\left(\frac{1}{0{,}9674.\,0{,}09802^{3{,}833}} - 1\right) + 482$$

$$< 823{,}96\ \theta_{cr} = 832{,}18℃ >$$

$$823{,}96℃$$

(Does not check)

Resistance Domain

$$R_{fi,Rd} \geq S_{fi,Rd}$$

$$117{,}1339\ (kN) \leq 200\ (kN)$$

(Does not resist)

The Chart 5 shows a summary of the calculation to determine the profile resistance, considering that the heat unprotected steel element has 3 of its sides exposed. According to NBR 14323:1999:

$\left(\frac{u}{A_g}\right)$ (m^{-1})	$\theta_a(t-\Delta_t)$ (℃)	φ_r (W/m^2)	φ_c (W/m^2)	φ (W/m^2)	$\Delta\theta_a$ (℃)	θ_a (℃)	$K_{y,\theta}$ -	$R_{fi,Rd}$ KN
161,05	803,53	5741,45	961,75	6703,2	1,15	804,68	0,10766	128,65

Chart 5: Resistance of the steel structural element, according to NBR 14323:1999

Verifications

Temperature Domain

$$\theta_{cr} = 39{,}19\ ln\left(\frac{1}{0{,}9674.K_{y,\theta}{}^{3{,}833}} - 1\right) + 482 < \theta_a$$

$$\theta_{cr} = 39{,}19\ ln\left(\frac{1}{0{,}9674.0{,}10766^{3{,}833}} - 1\right) + 482 < 823{,}96$$

$$\theta_{cr} = 818{,}09℃ > 803{,}53℃$$

(Does not chek)

Resistance Domain

$$R_{fi,Rd} \geq S_{fi,Rd}$$

$$128{,}65\ (kN) \leq 200\ (kN)$$

(Does not resist)

VIII. Conclusion

In this study, the fundamental concepts for the analysis of the resistance of steel structural elements subjected to a fire phenomenon were studied, using the simplified method of design used by ABNT NBR 14323 when submitted to an axial tensile load. In addition, it dealt with how the heat transfer from the flames to the structure occurs, also addressing the necessary checks of the safety conditions of the buildings.

It became evident how important that the mass factor is concerning the dimensioning of the structures under a fire situation. The larger the mass of the element is, the greater is its ability to absorb heat and withstand the thermal effect. On the other hand, its cooling will occur slowly. In cases where the mass of the element is small, the heat flow entering the element is characterized by rapidly raising the temperature of the profile, rendering its resistance capacity lower in a shorter time.

It was possible to verify that the non-consideration of the shading effect by the 1999 norm leads to conservative results, that is, the element has less design resistance. In the calculation of the radiation share the emissivity used by the 1999 standard is 0.5, which contrasts with the resulting emissivity of 0.7 adopted by the referred standard in 2013. Thus, it is not possible to verify a significant difference when comparing the methods to traction-moved elements.

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Assessment of Different Intersection Designs to Accommodate Left Turns through Indirect Maneuvers

By Hatem Abou-Senna, Essam Radwan & Hassan T Abdelwahab
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Abstract- Although there are studies that compared between indirect left-turn treatments such Median U-turn (MUT) or RCUT to the Conventional Intersection (CI) designs, very few have compared between the operational performances of MUT versus RCUT. Furthermore, few studies on the Quadrant Roadway Intersection (QRI) were found in the literature. The main objective of this paper is to assess different designs for the accommodation of left turns through indirect maneuvers. Traffic performance of the proposed intersection designs was evaluated based on micro simulation. The results revealed that the difference between the two designs, RCUT and MUT lies in the amount of traffic rerouted to the crossover intersections. Increasing the traffic downstream of the main intersection to the crossover intersection still has an effect on the main intersection's operations. Proper design and spacing is needed at the crossover intersection to mitigate this effect. The analysis also showed that at higher volume levels, RCUT throughput becomes restricted compared to the MUT which was attributed to the left turn effect at the main intersection. However, the RCUT showed 52% improvement over the MUT in average speeds. RCUT also showed 66% over MUT in delay savings and one year cost reductions when compared to the conventional intersection at 200% volume level.

GJRE-E Classification: *FOR Code: 290804*

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Hatem Abou-Senna [α], Essam Radwan [σ] & Hassan T Abdelwahab [ρ]

Abstract- Although there are studies that compared between indirect left-turn treatments such Median U-turn (MUT) or RCUT to the Conventional Intersection (CI) designs, very few have compared between the operational performances of MUT versus RCUT. Furthermore, few studies on the Quadrant Roadway Intersection (QRI) were found in the literature. The main objective of this paper is to assess different designs for the accommodation of left turns through indirect maneuvers. Traffic performance of the proposed intersection designs was evaluated based on micro simulation. The results revealed that the difference between the two designs, RCUT and MUT lies in the amount of traffic rerouted to the crossover intersections. Increasing the traffic downstream of the main intersection to the crossover intersection still has an effect on the main intersection's operations. Proper design and spacing is needed at the crossover intersection to mitigate this effect. The analysis also showed that at higher volume levels, RCUT throughput becomes restricted compared to the MUT which was attributed to the left turn effect at the main intersection. However, the RCUT showed 52% improvement over the MUT in average speeds. RCUT also showed 66% over MUT in delay savings and one year cost reductions when compared to the conventional intersection at 200% volume level. The assessment of the Quadrant Roadway Intersection (QRI) design revealed 12% increase in through put compared to the CI when CI reaches capacity with 48% increase in speeds and 66% reduction in delay. The cost of the connector roadway is the greatest cost and affects the total project cost depending on the available right of way. Some of the costs associated with the QRIs could be slightly compensated by the reduced widths at the main street intersection. Overall, QRI is significantly cheaper than the grade separation alternative.

I. Introduction

With increasing traffic and limited resources, the Florida Department of Transportation (FDOT) moves forward with a vision of optimizing intersection control through the implementation of innovative intersection designs through the Transportation Systems Management & Operations (TSM&O) program (1).

An alternative treatment that completely removes left turns at the intersection is the Median U-turn (MUT). MUT is an unconventional intersection alternative that helps reduce the number of signal phases and consequently the delay while at the same time improves the intersection traffic capacity (3). This technique has been utilized frequently in Michigan and is also known as Michigan U-turn. However, Autey et al (2012) concluded that the MUT design was unable to accommodate high approach volumes and heavy left-turn traffic compared to the crossover displaced left turn alternative (2).Hummer (1998) analyzed the MUT intersection and concluded that the MUT alternative may be utilized when there are high through arterial volumes, median, high left-turn volumes, and where the cross-street through volumes are insignificant (6). Hummer and Reid (8) provided an update to evaluate the capacity and efficiency of the MUT. The study concluded that the MUT may increase intersection capacity due to the reduction of signal phasing, but on the other hand it may decrease the capacity because of the vehicles using the crossover pass through the intersection more than once. The capacity may be also decreased due to the lack of approach lanes available.

Another version of the median U-turn is the Restricted Crossing U-Turn (RCUT) (5, 7). Inman and Haas (9) studied the operations, safety, and performance of RCUT intersections. Nine RCUT intersections were analyzed in Maryland and compared to the conventional intersections. Crash analysis was one of the variables analyzed; comparing the crash rate before and after the RCUT intersection was implemented. Results showed that although this method may add a little bit of travel time to the left turn users, it eliminates accidents and is consequently increasing the overall safety of the intersection.

The Quadrant Roadway Intersection (QRI) is another unconventional intersection design that may effectively accommodate high traffic volumes while eliminating the conventional left turns at the main intersection. Bared and Reid (2000, 2014) studied the operations, design, advantages and disadvantages of the QRI method (4, 10 & 11). The QRI uses an additional roadway to eliminate direct left turns from the main road

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at one quadrant of the intersection. The roadway should have at least three lanes to work efficiently and facilitate left turns. There is no specific quadrant that must be chosen, any of the four quadrants on the intersection would work properly. All the left turns on the main intersection are rerouted to the quadrant roadway. Safety has been a significant concern in conventional intersections with high turning volumes; QRI designs improve safety at these locations.

The main objective of this paper is the assessment of three different designs for the accommodation of left turns through indirect maneuvers which were recently proposed in Florida in order to test the concept. MUT, RCUT and QRI are still new in Florida and majority of the local public agencies are still reluctant to implement those new concepts. Each location has different challenges in terms of traffic operations that need to be addressed.

II. Case 1: U-turn Intersection Alternatives

The case study for the proposed U-turn intersection alternatives was conducted for the intersection of US 27 and Hartwood Marsh Road located in Clermont, Florida. This intersection was selected for the case study for couple of reasons. First, the intersection experience heavy traffic volumes on both the mainline and Side Street resulting in heavy congestion in the peak hours. Second, the mainline has a wide median suitable for the Median U-turn and is operated with high speed. So, this analysis was performed seeking a possible alternative of the existing intersection in order to minimize the delay and congestion for better traffic operations.

The intersection is 4-legged with Hartwood Marsh Road running east-west while US 27 running north-south. Hartwood Marsh Road is a 2-lane undivided roadway east of US 27 with posted speed limit of 40 mph, and it continues as 2-lane roadas Vista Del Lago Blvd with posted speed limit of 25 mph west of US 27. US 27 is a six lane divided principal arterial both south and north of Hartwood Marsh Road with posted speed limit of 55 mph. The east approach has one exclusive left-turn lane with storage length of about 550 feet, one through lane, and one exclusive right-turn lane with storage length of approximately 150 feet, whereas west approach consists of one exclusive left-turn lane with storage length of about 150 feet and one shared through- right-turn lane. On the other hand, the north and south approaches consist of one exclusive left-turn lane, three through lanes and one exclusive right-turn lane. The storage length of right-turn and left-turn lanes of the north and south approaches ranges from 400 to 550 feet.

a) Case 1: VISSIM Models

Performance of the proposed MUT and RCUT intersections was evaluated based on VISSIM 9 software. VISSIM incorporated all the necessary traffic characteristics in order to replicate the existing scenario. The evaluation involved existing conventional intersection (CI), MUT, and RCUT intersections. So, three separate VISSIM models were developed. Geometric designs of the MUT and RCUT intersections were developed based on the FHWA's median U-turn informational guide (11).

The model development process started with coding the network geometry of the existing intersection including number of lanes in each movement, storage lengths, roadway width, lane usage and width of the median. Traffic volume in each direction and in each movement was entered including its respective vehicle composition. Then, traffic signals and their corresponding signal timing plan were imported in the model. Actual signal timing data was received from the County and used for the conventional intersection. However, Synchro software was used to optimize the signal timing for the MUT and RCUT intersections. Detectors were also placed right before stop bar in each approach. Lastly, appropriate priority rules were applied at the necessary conflicting areas. Snapshot of VISSIM model for CI, MUT and RCUT intersections are shown in Figure 1.

In order to confirm that the model reflected the actual traffic characteristics and geometric condition, the model was calibrated and validated using field data including traffic counts, delay and queue lengths. Peak hour traffic counts were used in the validation that was extracted from the video file for the study intersection recorded on March 24, 2015.

To evaluate the operational performance of the three intersection configurations (CI, MUT, and RCUT), six levels of intersection traffic volumes were studied that varied from 100% (existing volume) to 200% with 20% increment in each level. Therefore, a total of 18 experiments (scenarios) were performed and evaluated. Each experiment was simulated for 60 minutes. A total of ten runs with different seeding values were completed for each scenario and the average of the 10 runs was reported for the analysis. Synchro software was used to estimate the optimum traffic signal cycle length and splits for each scenario. Several trials for different signal timing plans were tested in VISSIM to find out the best signal timings based on the overall network performance.

(a) Conventional Intersection

(b) MUT Intersection

(c) RCUT Intersection

Figure 1: VISSIM Models for Study Case 1

b) Case 1: Results and Analysis

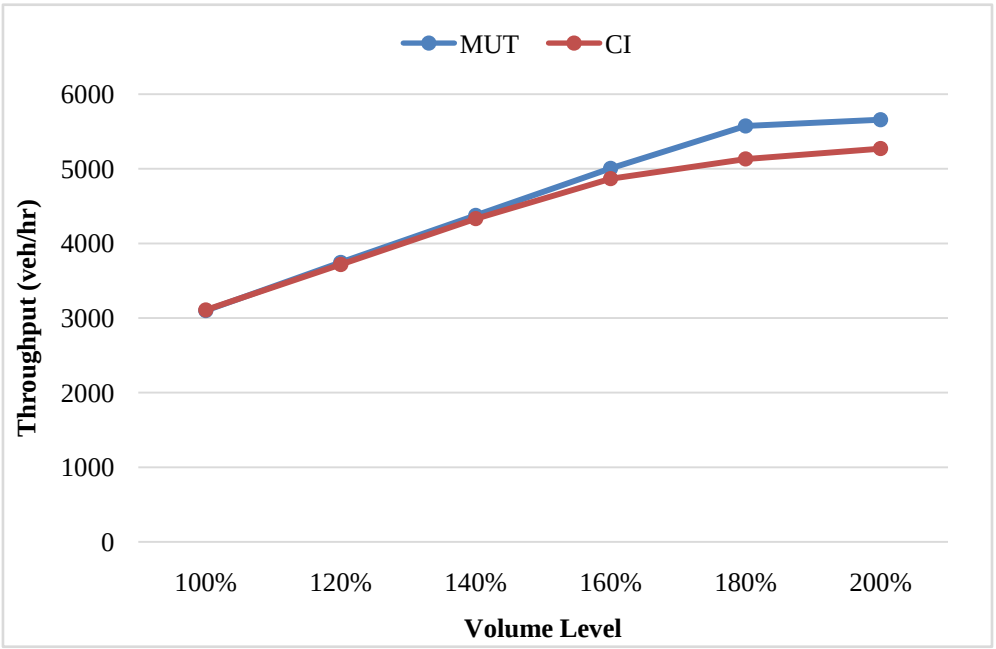
i. *CI and MUT*

The comparison between the existing conventional design and the MUT proposed design was performed based on the simulation results obtained from VISSIM output for each scenario. A comparison of the hourly throughput volumes between CI and MUT at each volume level is illustrated in Figure 2a. The MUT

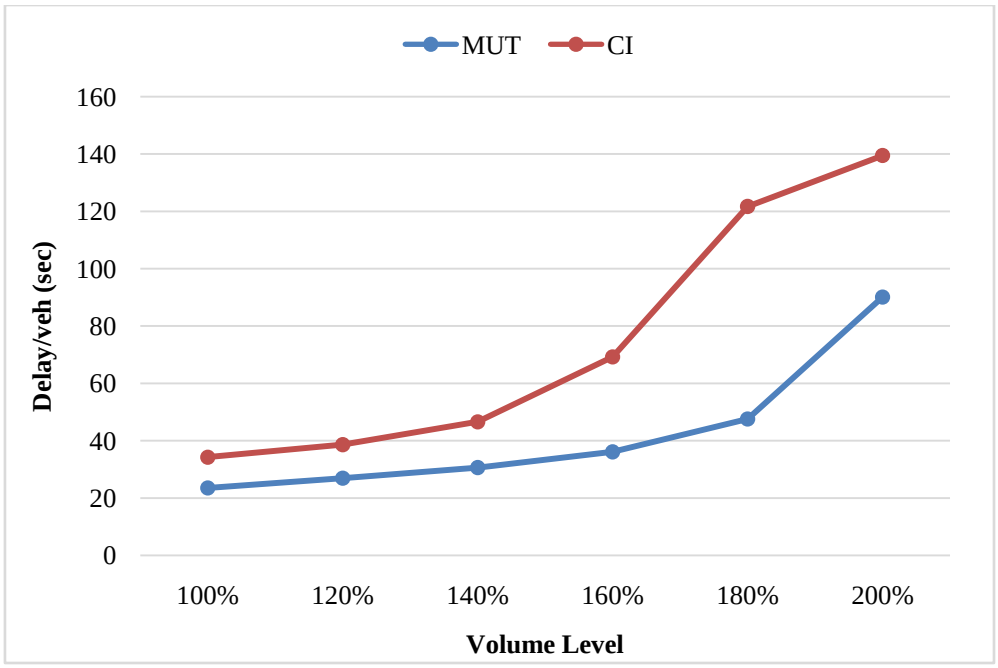
intersection throughput outperformed the CI throughput starting from the 140% volume level, which is an indication of the limited capacity of the CI. The change in hourly throughput volume between the CI and MUT ranged from about 3% to 8%. Trend of delay per vehicle for each volume level was also plotted between MUT and CI as shown in Figure 2b. The difference in overall delay could be seen in each volume level but it was maximized at 180% volume level at which CI reached its capacity. The overall travel time also followed the same pattern as delay and showed improvement for MUT up to 37%. Level of service was also improved in each volume level. Based on the results, it can be concluded that MUT intersection design considerably enhanced the overall operation and capacity over CI. The throughput volume was observed significantly less than the input volume around 180% for conventional intersection and around 200% for RCUT intersection, which is an indication of capacity constraint of the conventional intersection.

ii. *CI and RCUT*

Figure 3a demonstrates the hourly throughput volume for CI and RCUT for each volume levels. The throughput volume increased for RCUT compared to CI, although the change was not very large (up to 5%). Figure 3b showed the relationship between delay per vehicle and volume level for CI and RCUT. The difference in overall delay was observed in each volume level but the highest was observed at 180% volume level as shown in Figure 3b. As mentioned earlier, the capacity was reached for CI at around 180% volume level that produced the maximum difference in delay between CI and RCUT intersection. The overall travel time also followed the same pattern as delay and showed improvement for RCUT up to 40%. Level of service and average speed was also improved in each volume level. RCUT design outperformed CI in each measure of performance for the overall network.

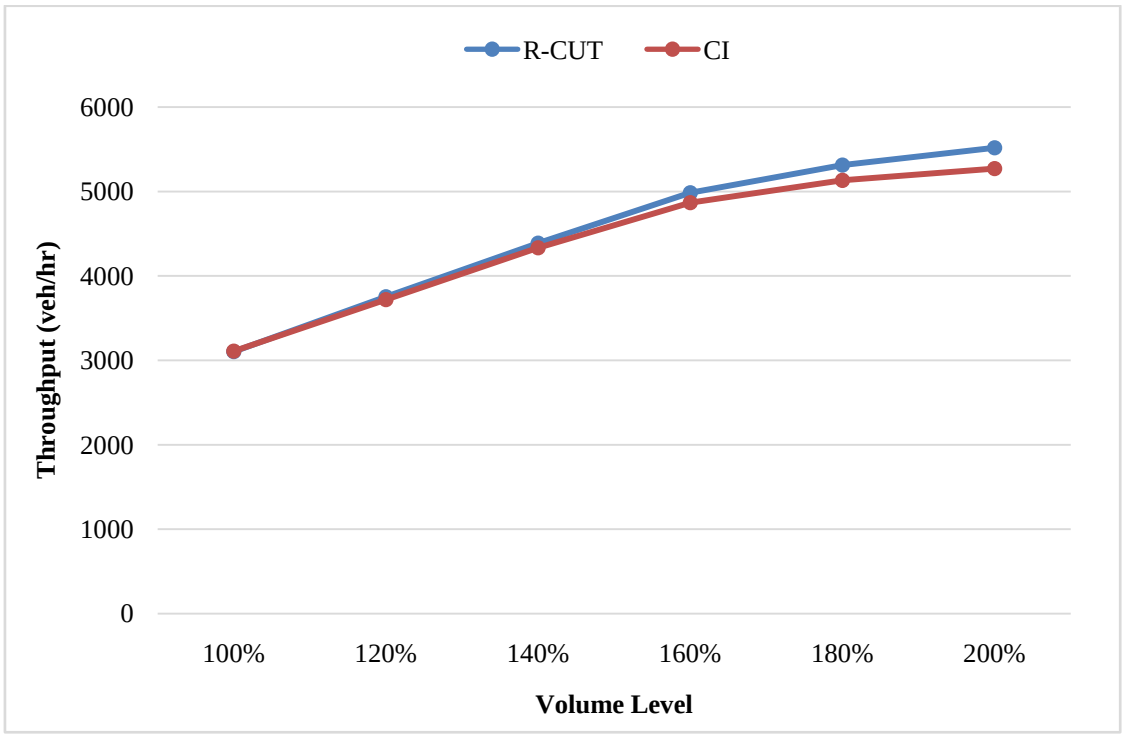


(a) Hourly Throughput

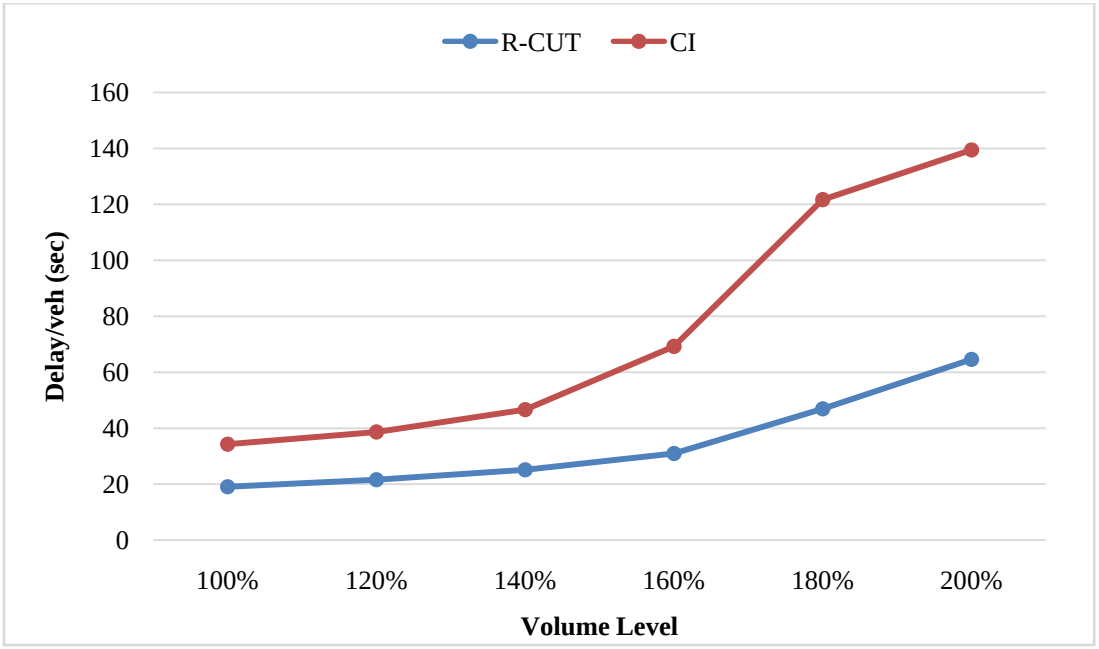


(b) Volume Level versus Delay per Vehicle

Figure 2: Comparision between CI and MUT



(a) Volume Level versus Hourly Throughput



(b) Volume Level versus Delay per vehicle

Figure 3: Comparison between CI and MUT

iii. *MUT versus RCUT Intersections*

Table 1 represents the overall network performance in terms of hourly throughput volume, delay per vehicle in seconds, level of service, average speed, and total travel time. RCUT was slightly superior to MUT design on the basis of operational performance. The overall delay in each volume level is reduced for RCUT compared to MUT intersection. RCUT also improved average speed and total travel time. The results showed that the RCUT design provided 25% improvement in average speeds at the low volume level and as the volume increases, more benefits were seen reaching up to 75% improvement in average speeds. However, there is a slight reduction in the throughput (up to 5%) as the demand increases in the RCUT compared to the MUT. This may be attributed to the fact that the main line left turn traffic is still utilizing the main intersection and as the left turn increases, the conflict with the opposing thru increases affecting the green time at the main intersection, which in turn affects the throughput when compared to the MUT design. Certain approaches with high volume played the role for better performance of RCUT over MUT. The operation of left-turns at major road and through movement at minor road differed in MUT and RCUT. NBL and SBL in MUT design required to use U-turn crossover while EBT and WBT in RCUT design required using U-turn crossover.

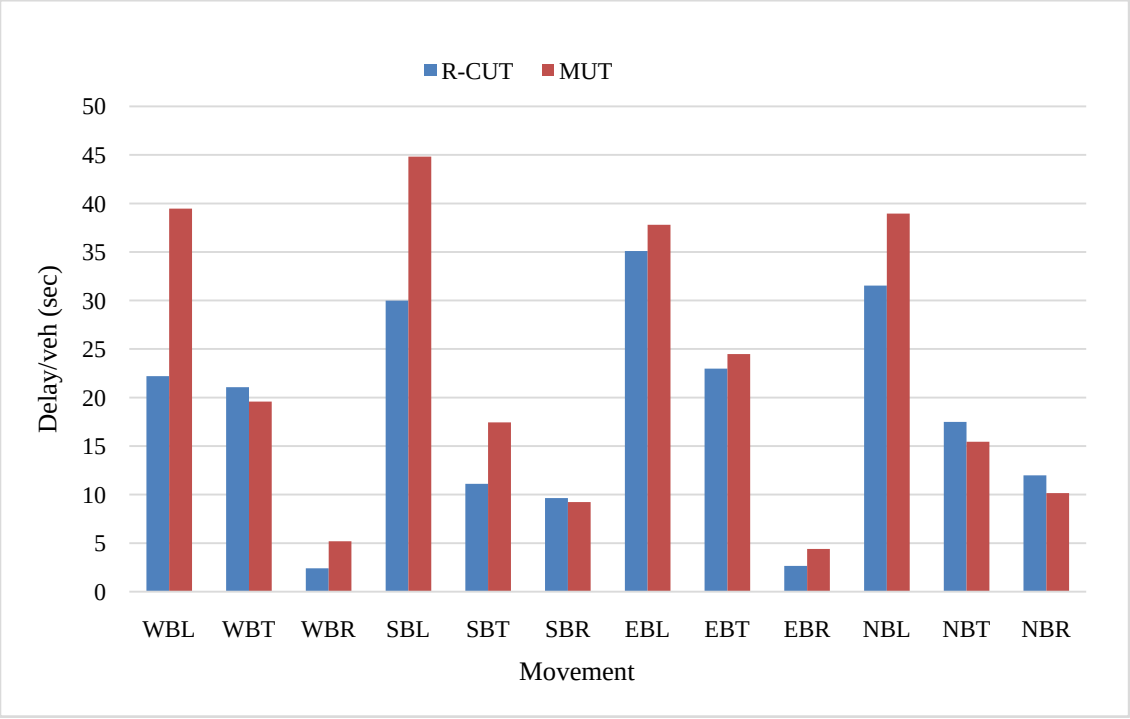
Table 1: Overall Network Performance Measures for CI, MUT, and RCUT

Intersection Treatment	Volume Level	Input Volume	Throughput	Delay/veh (sec)	LOS	Average Speed (mph)	Total Travel Time (sec)
Conventional	100%	3,183	3,100	34.29	C	39.07	224,064
	120%	3,820	3,718	38.66	D	36.79	285,015
	140%	4,456	4,332	46.62	D	33.25	368,453
	160%	5,093	4,868	69.26	E	26.05	529,787
	180%	5,730	5,132	121.71	F	17.12	855,723
	200%	6,366	5,271	139.47	F	15.31	977,035
MUT	100%	3,183	3,108	23.53	C	49.99	222,476
	120%	3,820	3,746	26.93	C	47.69	281,277
	140%	4,456	4,376	30.64	C	45.43	345,640
	160%	5,093	5,007	36.12	D	42.43	423,838
	180%	5,730	5,576	47.59	D	37.28	539,097
	200%	6,366	5,659	90.13	F	25.38	802,292
RCUT	100%	3,183	3,103	19.09	B	52.25	206,142
	120%	3,820	3,753	21.58	C	50.36	258,195
	140%	4,456	4,387	25.15	C	47.83	318,049
	160%	5,093	4,984	30.97	C	44.26	391,065
	180%	5,730	5,312	46.94	D	37.20	505,888
	200%	6,366	5,517	64.61	E	30.60	635,138

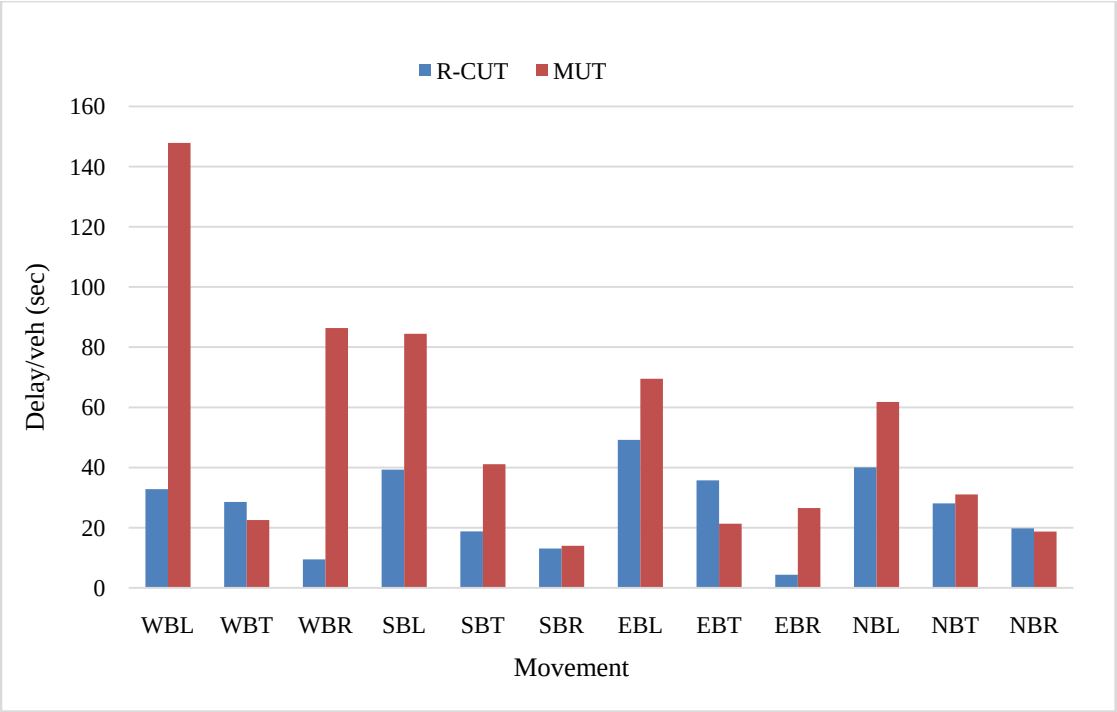
Figure 4b shows the comparison of delay by movements between RCUT and MUT for 100% and 200% volume level respectively. The major difference in delay was observed for WBL and SBL movement. In the study intersection, the volume of the WBT and EBT movements were comparatively less in comparison to SBL and NBL movement as shown in Figure 4a. In addition, the NBL volume was very light compared to SBL that increased the green time proportion in SBT direction in RCUT design. According to the design, WBL goes through SBT movement, which showed the advantage of RCUT over MUT for that particular movement of the study intersection. On the other hand, direct through movement of WBT and EBT traffic in MUT intersection was the main benefit over RCUT. However, the volume in WBT and EBT movement was considerably lower compared to SBL and WBL movement. Therefore, the improved operations of WBL, SBT and SBL movements in the RCUT design showed that RCUT was a better alternative than MUT for the study intersection. The analysis also revealed that improvement in the throughput in the MUT and RCUT compared to the CI was observed at the 160% volume level. However, delay improvement was observed at the 140% for RCUT while 160% in the MUT. The results indicate that increasing the traffic downstream of the main intersection to the crossover intersection still has an effect on the main intersection's operations. The difference between the two designs, RCUT and MUT is the amount of traffic rerouted to the crossover intersections. Proper design is needed at the crossover intersection to reduce its effect on the main intersection. Although the MUT showed slightly higher throughput compared to the RCUT in the range of 5%, the RCUT showed 52% improvement over the MUT in average speeds.

iv. *Benefit to Time Saving*

Generally, MUT had moderate benefit-to-cost ratio when compared to the conventional intersection. The cost of converting a conventional intersection to an MUT intersection varies depending on the specific project context. The cost of MUT intersection depends on several aspects such as the number and length of additional lanes required, utility impacts, modifications to the existing signal system, amount of additional right of way, and access modifications. The right of way cost may change by geographical location. For the study intersection, delay savings by MUT and RCUT intersection compared to conventional intersection was calculated as shown in Table 2. The cost of delay of $17.67/hr. was used as reported by Texas A&M Transportation Institute for year 2014.



(a) 100% Vol Level



(b) 200% Vol Level

Figure 4: Intersection Delay by Movements Comparison between RCUT and MUT

Table 2: Cost Saving of Case 1

Volume Level	Total Travel Time Reduction (vehicle-hour/day)		One-year Cost Reduction (dollar)	
	MUT	RCUT	MUT	RCUT
100%	56.47	79.93	$364,235	$515,513
120%	72.57	106.74	$468,034	$688,424
140%	116.42	157.31	$750,838	$1,014,577
160%	271.62	317.57	$1,751,842	$2,048,173
180%	499.30	532.14	$3,220,255	$3,432,083
200%	413.74	685.28	$2,668,443	$4,419,720

c) *Case 2: QRI Design*

The main objective of this case study is the assessment of Quadrant Roadway Intersection (QRI) to reduce traffic delays at congested 4-leg signalized intersections. The intersection under study is located in Orlando, Florida along Dean Road at University Boulevard as shown in Figure 5a. The intersection is 4-legged with Dean Road running in the north-south direction while University Boulevard running east-west. Dean Road is a 4-lane divided road south of University Boulevard and 2-lane divided road north of University Boulevard with posted speed limit of 45 mph. Similarly, University Boulevard is operated as a 6-lane divided road in both east and west direction with speed limit of 45 mph. This is the main road leading into the University of Central Florida, the second largest university in the Country in terms of student enrollment. The intersection experience heavy traffic in the PM peak hour both on the main line through and left turn as well as the crossing road (Dean Road). Dean Road has two exclusive left-turn lanes, and two through lanes one of them shared with right turn on south approach, and it has two exclusive left-turn lanes, two through lanes, and one exclusive right-turn lane on north approach. University Boulevard has two exclusive left-turn lanes and three through lanes one of which is shared with right turn on east approach, while it has two exclusive left-turns, three through lanes and one exclusive right turn lane on the west approach. The storage lengths in all approaches ranges from 300 to 400 feet except on west approach which is extended all the way to SR 417 north exit on University Boulevard. All the left-turn movements operate with protected phases only and right-turn movements should yield to the conflicting movements. This intersection is considered appropriate for Quadrant Roadway Intersection (QRI) design because it is experiencing recurring congestion in the PM peak hours. The through traffic in east-west direction is heavy and

other movements including all left-turn movement, has moderate traffic. In addition, there is an existing roadway in the southeast quadrant where the quadrant roadway as in Quadrant Roadway Intersection design could be operated. Therefore, a QRI design was evaluated as the build scenario and compared to Conventional Intersection (CI) in search of a rational alternative to minimize the intersection congestion especially for future conditions.

For the study intersection, 4-lane one-connecting roadway quadrant located at the southeast quadrant of the intersection was designed for the evaluation. There was an existing quadrant road where the new roadway quadrant can be constructed. However, a wider 4-lane quadrant roadway connector was designed as shown in Figure 5b. Therefore, the additional right-of-way for the wider roadway is needed for the study intersection. The QRI design has three signal-controlled intersections, which included the main intersection, reduced to a two-phase signal and two new T-intersections with three-phase signals at the ends of the quadrant road.

d) Case 2: VISSIM Modeling

The comparison of operational performance between QRI and conventional intersection was made using results from VISSIMtraffic micro simulation software. The VISSIM model was drawn over the properly scaled background picture of the study intersection obtained from Google Map. Number of lanes in each movement, storage length and other geometric features were set up same as the study intersection. Then, traffic volumes and signal timing data were assigned in each movement group. Actual signal timing data was obtained from Orange County. The VISSIM model was calibrated and validated using the field data collected for the study intersection.For the analysis, comparison between CI and QRI was performed in different volume level scenario. Based on the existing traffic volume demand, five volume levels, increasing 10% volume in each volume level, were set up. Therefore, the final experiment resulted in 5*2=10 multilevel factorial. For each volume level, an optimized signal timing plan was used. Synchro was not the best for the signal optimization, but it gave an estimate for the optimized cycle length and splits. Therefore, many trials for different signal timing plans were tested in VISSIM to figure out the best signal timings based on the overall network performance. Additionally, each experiment was simulated for 60 minutes. A total of 10 runs with different seeding values were completed for each scenario and the average of the runs was reported.

(a) Case Study 2 Intersection

(b) Case Study 2 QRI Design

Figure 5: QRI Design for the Study Intersection of Case 2

e) Case 2: Results and Analysis

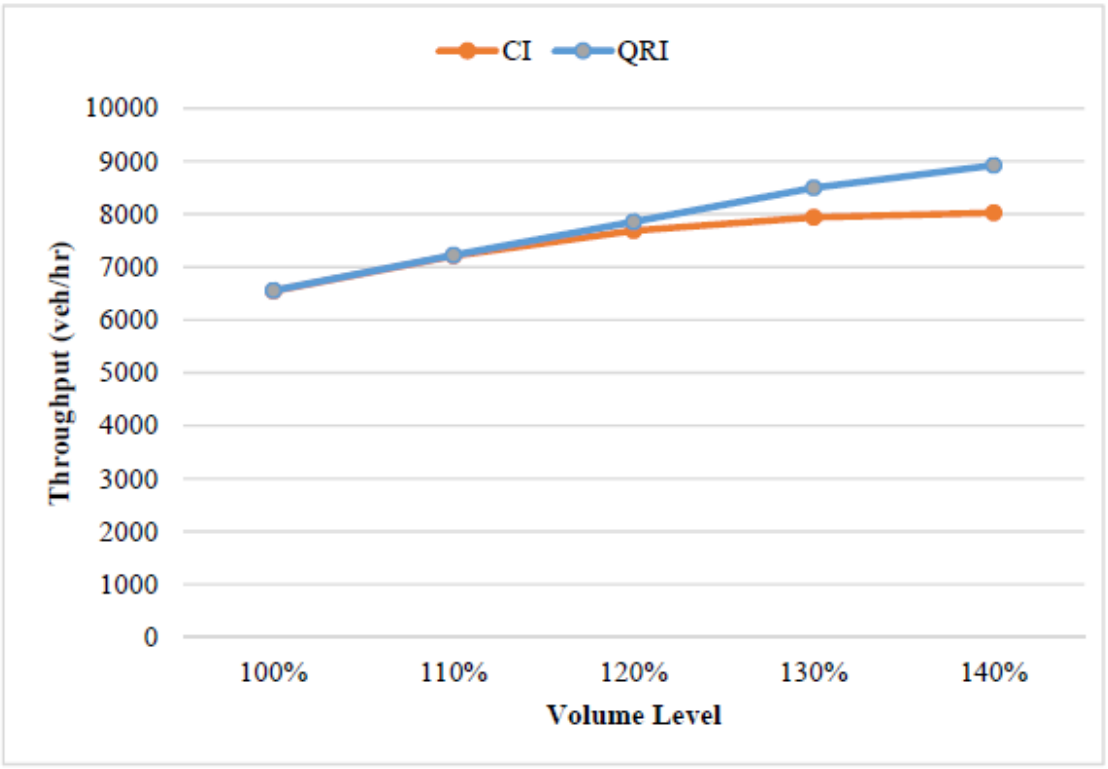
The overall network performance of CI and QRI at each volume level is presented in Table 3. The overall network performance measures included hourly input volume, hourly throughput volume, delay per vehicle, level of service, and average speed. The throughput volume for CI differed from input volume significantly around 120% to 130% volume level, which indicated the capacity of the existing intersection. Comparison can be made based on the overall performance results when the conventional intersection is changed to QRI design as showed in Figure 6. The difference in throughput volume between CI and QRI was obvious past volume level of 120%. Improvement in delay was observed past the 110% volume level. QRI showed delay savings in each volume level ranging from 35 to 57% with the highest value at 130% volume level when compared to CI. When comparing the input and the throughput percentages between the CI and QRI at the 140% volume level, 95% of the input was processed for the QRI, while 85% only from the CI. This result indicates that QRI throughput is 12% more than the CI when CI reaches capacity.

Table 3: Overall Network Performance Measures for CI and QRI

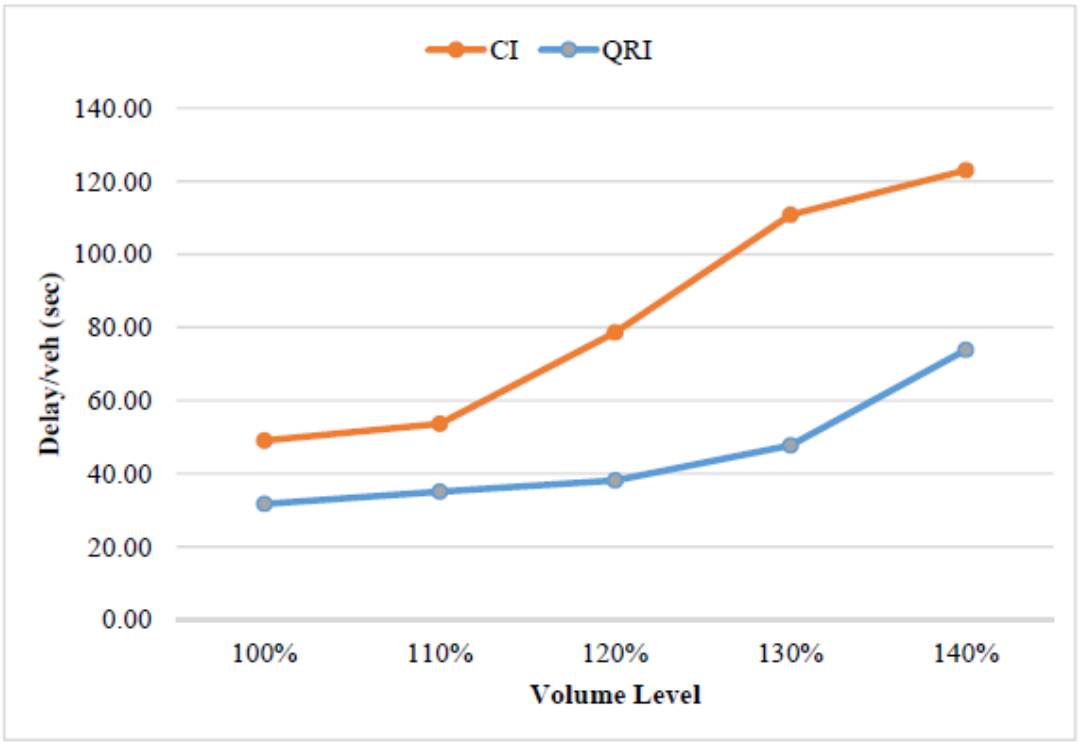
Intersection Treatment	Volume Level	Input Volume (Veh/hr)	Throughput (Veh/hr)	Delay/Veh (Sec)	LOS	Average Speed (mph)
Conventional	100%	6675	6544	49.02	D	33.83
	110%	7343	7209	53.60	E	32.23
	120%	8010	7685	78.61	E	25.57
	130%	8678	7937	110.79	F	19.96
	140%	9345	8023	122.99	F	18.45
QRI	100%	6675	6555	31.68	C	42.18
	110%	7343	7224	35.07	D	40.45
	120%	8010	7853	38.13	D	38.97
	130%	8678	8495	47.73	D	35.03
	140%	9345	8919	73.83	E	27.33

Additionally, QRI also improved the level of service and average speed in each volume level. Average speeds increased by 48% translating into 66% reduction in delay. Therefore, it can be concluded that QRI can enhance the capacity and improve the overall network performance in the study intersection. The operational performance measure by movement was also compared between CI and QRI. At 100% volume

level, the delay was improved in all movement except one movement (EBR). Similarly, level of service and travel time also improved in most of the approaches. The QRI design in the study intersection had some indirect left-turn movements such as EBL, NBL, and SBL, which required to travel longer distance and going through multiple signalized intersections.



(a) Volume Level versus Hourly Throughput



(b) Volume Level versus Delay

Figure 6: Comparison between CI and QRI

f) Benefit to Time Saving

Construction costs for QRIs are likely higher than a conventional intersection. However, QRI produces moderate to high benefits over conventional intersection. Main components that are needed and add to the cost include the connector roadway, additional signals and overhead signs for the two extra intersections. On average, the connector roadway is about 880 feet (centerline to centerline), or 0.167 miles with 500 feet spacing between the main and secondary intersections. The average right of way is about 1.1 acres. Other costs are related to lighting, maintenance costs and enforcement needs especially during the first months of operations. The cost of the connector roadway is the greatest cost and affects the total project cost depending on the available right of way. Some of the costs associated with the QRIs could be slightly compensated by the reduced widths at the main street intersection. The right of way cost may change based on the geographical location of the intersection.

For the study intersection, the existing road located in southeast quadrant of the main intersection was used as a connector roadway. Therefore, project costs related to land acquisition for the connector roadway will be reduced. However, there will be some right of way cost for widening to four lanesto accommodates the left turn traffic volume. Delay savings by QRI compared to conventional intersection was calculated. Table 4 shows the benefit of QRI over CI in terms of delay savings in one year.

Table 4: Cost Reduction based on Delay saving

Volume Level	Total Travel Time Reduction (vehicle-hour/day)	One-year Cost Reduction (dollar)
100%	194.06	$1,251,600
110%	228.53	$1,473,916
120%	535.8	$3,455,669
130%	849.35	$5,477,925
140%	593.31	$3,826,583

III. Conclusions

This study underlined the important aspects of MUT intersection operation and showed the improvement in operational performance in case of MUT compared to the existing condition. MUT design significantly reduces the number of conflicts at the main intersection, which offers a better operation and safety for motor vehicles, pedestrians, and bicyclists. The two-phase signal timing plan provides higher percentage of green time for through movements that ensures a better through operation. However, the left-turn movements may experience higher delay and travel time due to their indirect left-turn movement through U-turn crossover. The analysis highlighted several important aspects regarding RCUT traffic operations and demonstrated how RCUT can improve the overall performance compared to the existing condition. RCUT intersection reroutes through and left-turn movements from the minor streets to the median U-turn crossover, providing an easier maneuver at the major street. RCUT intersection design significantly reduces the number of conflicts at the main intersection, leading to a more efficient and safer operation. Only two phases are required at the main intersection to accommodate the vehicles and pedestrians, which ensures a better operation at the major street. However, the movements at the minor road may experience higher delay and travel time due to their indirect movement using U-turn crossover. Vehicle-pedestrian conflicts are reduced significantly through the use of a “Z” shaped crossing in RCUT intersection although it may increase the crossing time a little bit.

The results showed that the RCUT design provided 25% improvement in average speeds at the low volume level and 75% in the higher level. However, there is a slight reduction in the throughput (up to 5%) as the demand increases in the RCUT compared to the MUT. This may be attributed to the fact that volume increase in the left turns as well as the through traffic at the main intersection increases the conflict with the opposing thru resulting in reduced green time affecting the throughput. However, overall speeds and delays outperformed the MUT due to the rerouting of all lefts and side street traffic to the crossover intersection. The case study also showed that RCUT design for this location is better than the MUT design since it reduced the overall delay and travel time, and improved the level of service compared to the conventional intersection. The RCUT design outperformed the conventional intersection and the MUT in terms of delay and travel time for increased volume scenario as well. Overall, RCUT intersection was the selected alternative for this location.

The analysis also highlighted several important aspects regarding QRI traffic operations and demonstrated how QRI can improve the overall performance compared to the existing conditions. QRI is applicable mainly for intersections with two busy sub-urban or urban roadways. QRI reroutes all four left-turn movements in a four-legged intersection using a secondary roadway connecting two intersecting

roadways. Only two phases are required at the main intersection to accommodate the vehicles and pedestrians, which allocates higher percentage of green time for through movements. QRI throughput is 12% more than the CI when CI reaches capacity. Additionally, QRI also improved the level of service and average speed in each volume level. Average speeds increased by 48% translating into 66% reduction in delay Therefore, it can be concluded that QRI can enhance the capacity and improve the overall network performance at the study intersection which is a cheaper solution than the grade separation alternative. Elimination of left-turn lanes at main intersection provides a shorter crossing distance for pedestrians and bicyclists. Pedestrians and bicyclists get less waiting time due to the shorter cycle length at QRI. Way finding is very important at QRI especially for left-turning drivers who are not familiar with the intersection. QRI intersections can provide a superior alternative to heavily congested conventional intersections in terms of overall operational performance.

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Predicting Dry Density of Soil from Some Physical and Chemical Properties

By Dhurgham Abdul-Jaleel Rasool Al-Hamdani, Hana Mahmoud Amer Al-Kasaar & Hussain Ali Muhammad Zani

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Keywords: *regression, liquid limit, plastic limit, correlation, water content, density.*

GJRE-E Classification: *FOR Code: 290899*

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Predicting Dry Density of Soil from Some Physical and Chemical Properties

Dhurgham Abdul-Jaleel Rasool Al-Hamdani [α], Hana Mahmoud Amer Al-Kasaar [σ]
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I. Introduction

Soil density, characterized as the evident density of field soil and ascertained from the stove dry mass per unit volume of field soil, is an imperative soil property that outlines general soil auxiliary attributes. It is a crucial information necessity for all intents and purposes every numerical model portraying the exchange and connection of soil substance constituents inside the ecosphere. Mass thickness is a generally straight-forward property to gauge and a number of broad datasets have been accumulated (Hall et al., 1977; Rawls et al., 1981). Along these lines, few endeavors have been made to create approachesp;o0 for its forecast from other essential soil properties. Be that as it may, the expanding enthusiasm for creating far reaching national datasets of soil physical properties for use in spatially-or stochastically-based ecological demonstrating (King et al., 1995; Bruand et al., 1996) has unavoidably featured discontinuities in the current estimated datasets. This thusly, has now centered consideration around the need to create algorithmic techniques that can anticipate variety in mass thickness as indicated by the consistent variety of soil properties, for example, molecule size and natural issue content. A few researchers focusing to estimate soil density depending on its physical and chemical properties empirically. Simple and Multiple linear regression were utilized for correlation the physical and chemical properties with soil density. Some of this relationship is shown in Table (1). In this table, the researchers developed limited number of empirical formulae while other researchers focusing on presenting the general behavior of the relation between density with chemical and physical properties. Most of correlation that publish pure empirical formulae which is created byutili zings Data Analysis Tool Bar in Microsoft Excel. As a sample of the relation which explain the general behavior is the relation developed by Tanveera A. et al. (2016); they correlate bulk density with many soil property like (texture, organic matter, and mineral friction as sand, silt, and clay). Twenty five soil samples collected from different a location in Kashmir valley in India. The depth of collected samples ranged between 20 to 35 cm. they conclude that the relation between bulk density and organic matter, porosity, and present of clay minerals are positive with present of sand. The relation of the physical and chemical properties with soil bulk density as mentioned by Traveera et al. are shown in models are shown in (Table 1). This relation created byusing Microsoft Excel. Andres A. (2004), he analyze eight sandy soil samples by conducting maximum dry density, soil classification and measuring the fines content and the uniformity coefficient of these samples. He correlate some of physical properties with the maximum dry density. The correlation were measured and some specific behavioral patterns were encountered and analyzed. He conclude that the correlation between well graded sands and maximum dry density have high coefficient of determination, while the poorly graded sand is lower. Thecorrelation model sproposed by Andres A. was developed using Data Analysis Tool Bar in Microsoft Excel. These correlations are shown in Table (1). Chaudhari, P. R. et al. (2013), They investigate the relations of bulk density of soil with texture, organic matter content have available quantity of macro and micro nutrient. Eight soil samples utilized in this investigation. They conclude that the relationships with all soil properties under investigation are negative relation except the relation with sand content. Besides texture and optimum moisture content, organic matter

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was also the most effective factor affected on the bulk density of soils. The concluded relation was developed using Data Analysis Tool Bar in Microsoft Excel. These correlations are shown in Table (1).S.H. Hallett, et al. (1998)they utilized the procedure of Rawls (1983) to estimate the bulk density of 1568 soil samples within Wales and England. The present of sand, silt, clay, organic matter and the bulk density were the available data utilize in these procedure. The principle of Rawls procedure is predicting bulk density as dependent variable on other soil properties as independent variables. The relations developed by utilizing Rawls procedure are presented in Table (1).

Table 1: The formula proposed by the other researchers

Researchers	Level of Significance	R^2	Function	Density function of
Tanveera A. et al. (2016)	Significant increase	0.60	-	Sand %
	Significant decrease	0.41	-	Clay %
	Significant decrease	0.75	-	O.M. %
	Significant decrease	0.52	-	n
Andres A. (2004)	Significant increase	0.906	$\gamma_d = 87.715(C_u)^{0.166}$	Clean sand %
	Slightly in poorly graded sand and Significantly in poorly graded sand	-	-	%Fines
	Significantly increase and then slightly increase in low and high plasticity Clay.	-	-	%Fines
Chaudhari, P. R. et al. (2013)	Significant increase	0.909	-	Sand%
	Significant decrease	0.633	-	Clay%
	Significant decrease	0.734	-	Silt%
	Significant decrease	0.886	-	n
	Significant decrease	0.495	-	CaCO3
	Significant decrease	0.661	-	EC
	Slightly decrease	0.2317	-	pH
	Significant decrease	0.887	-	OMC
S.H. Hallett, J.M Hollis and C.A. Keay (1998),	For 8 samples	0.65	$\gamma_b = 0.618 + 0.095LogeSilt + 0.100LogeClay + 0.0195LogeSand - 0.178Loge OM$	Silt,Clay, Sand, OM
	For 16 samples	0.64	$\gamma_b = 5.01 - 0.931LogeSilt + 0.038LogeClay - 0.173LogeSand - 0.365Loge OM$	Silt, Clay, Sand, OM

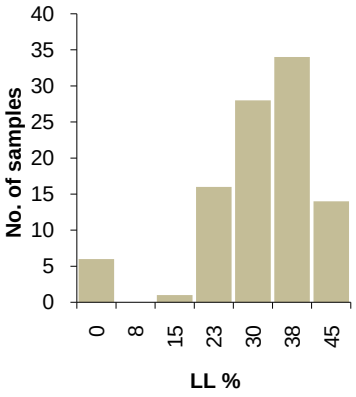
The main purpose of this work is to develop a new correlation system using regression analysis to predict the dry density of soil from physical and chemical properties. The outcomes of this work can be summarized as Develop many simple and multiple correlations model to predict dry density by using regression analyses to decide the best correlation may use to estimate the value of dry density.

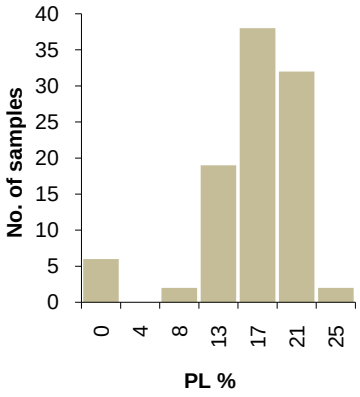
II. Materials and Methods

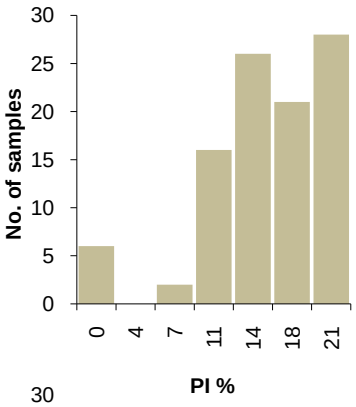
The soil which used in this study is collected from site investigation reports. The soil sample includes different size collected from different locations in Al-Najaf Al-Ashraf City. A ninety-nine of disturbed soil samples were used in this study. The samples were taken from reports of pavement projects and exploration reports during the period from 2005 to 2017. The reports are prepared by scientific and advisory consultant bureauin Al-Najaf Technical Institute. All the tests in reports prepared according to ASTM standards. The selected soil samples include plastic and non-plastic materials. The soil parameters which collected and utilized in the database include organic matter (OM), total suspended solids (TSS), sulfate content (SO_3), natural water content (ω), present fines (F#200), liquid limits (LL), plastic limits (PL), plasticity index (PI), specific gravity (G_S), and dry density (γ_{dry} or γ_d). So as to survey the ampleness of the database, engaging measurements of each dataset exhibits in the database were resolved. Table (2) introduces the elucidating insights of every factor. While the histogram conveyance of the database is appeared in Figure (1). As per the outcomes that show up in Table (2), it can be inferred that the database comprises of an accessible scope of information. In this manner, this database can be utilized for the examination of the execution of existing observational formulae with the correct esteem.

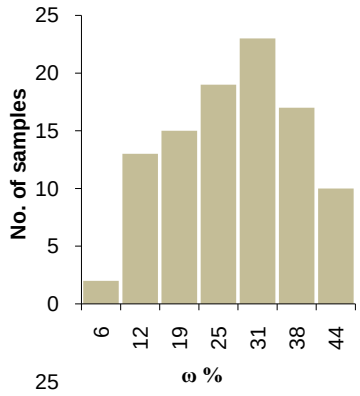
Table 2: Statistical analysis of utilized database

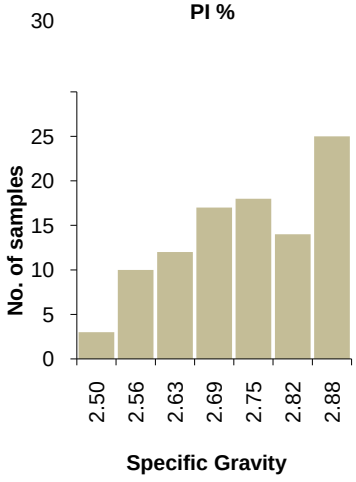
Soil Properties	LL	PL	PI	WC	Gs	F#200	TSS	SO_3	OM	γdry
No. of sample	99	99	99	99	99	99	99	99	99	99
Maximum	45	25	21	44	2.88	57	7	6	8	2.25
Minimum	0	0	0	6	2.5	12	0.02	0.01	0.01	1.5
Range	45	25	21	38	0.38	45	6.98	5.99	7.99	0.75
Mean	27.97	14.11	13.77	24.15	2.71	31.25	2.68	1.86	2.59	1.82
Median	30	15	14	25	2.72	31	2.3	1.5	1.8	1.79
Standard dev.	9.694	4.779	5.077	10.048	0.108	11.994	2.057	1.757	2.494	0.184
Units	%	%	%	%	-	%	%	%	%	gm/cm³

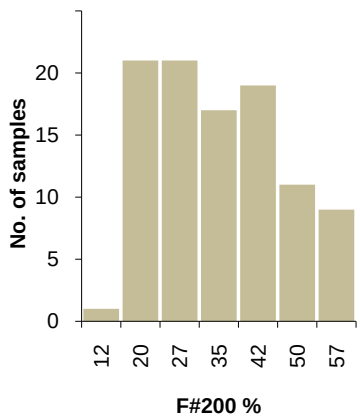












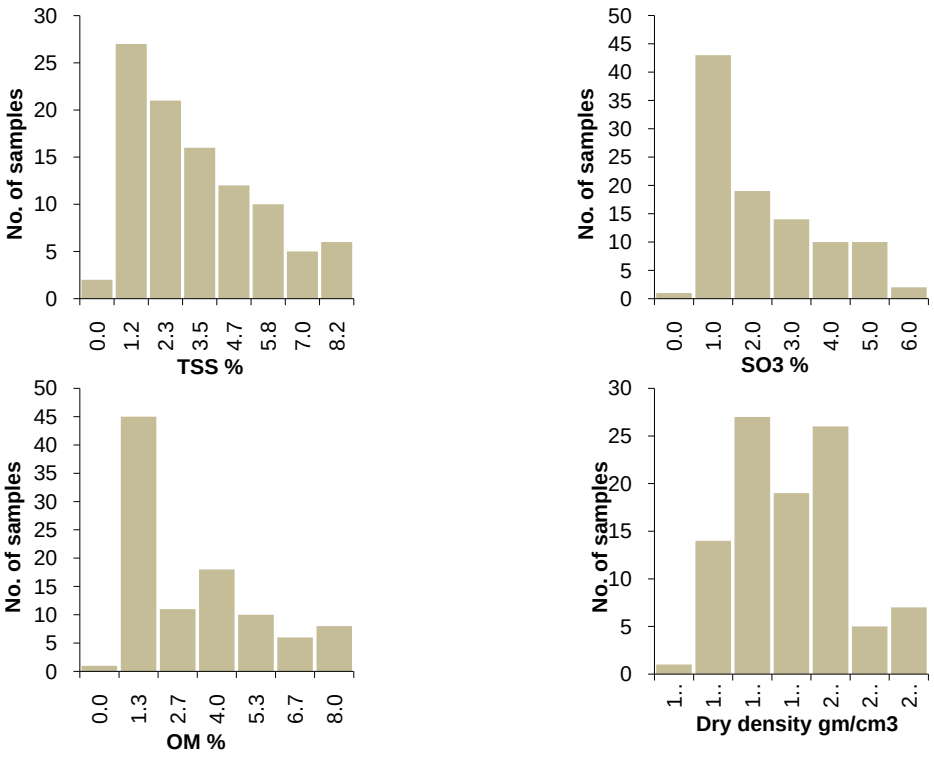


Figure 1: Histogram distribution of database utilized in this study

III. Results and Discussion

Relapse examination is a factual procedure used to assess the connections between factors. It is utilized to comprehend which one of the reliant factors are identified with the free factor and to investigate the types of these connections. Both Single regression analysis (SRA) and multiple regression analysis (MRA) were created in this examination to appraise the value of dry density in view of a portion of the physical and chemical properties by utilizing the chose database.

The trucks choice from Excel was utilized to chart the qualities acquired from the analyses, it was likewise connected an element that is equipped for including a non-straight pattern line to a predetermined arrangement of focuses. The pattern line is a bend characterized from pre-decided capacities, for example, Polynomial, Logarithmic, Power and Exponential. Additionally, the R-squared, known as the coefficient of assurance, can be computed. The R-squared esteem is a pointer that reaches from 0 to 1 and uncovers how intently the assessed esteems from the pattern line compare to the genuine information. The pattern line is more solid when its R-squared esteem is at or close to 1. The chose slant line was unified with the most elevated R-squared esteem. The power work was the nearest guess to the arrangement of focuses got from the tests, this condition has a highest R-squared estimation.

a) Simple Regression Analysis

SRA is the most commonly basic type of regression and utilized in the predictive analysis. There are two things represent the main idea of simple regression analysis: the first is providing the set of predictor variables with good accuracy in predicting an outcome value of the variable, the second, is providing significant predictors variable as a dependent variable. To establish a simple regression between dry density and physical and chemical soil properties, many point are drawn as the (X) coordinate represent the specified soil property and the (Y) coordinate represent the dry density. The best fit line pass through and discussed the variation of most point is the simple regression line, the equation of this line simulate the relation between soil property utilized and dry density. The accuracy of SRA measured by calculating the coefficient of determination (R2). It is a number which explained the reliability of proposed proportion. The coefficient of determination ranged between 0 to 1. The best correlation is the correlation has the coefficient of determination closest to 1. Practically, the value of coefficient of determination equal or greater than 0.8 indicates the acceptable correlation. To develop the models of SLRA on the available database. Data Analysis Tool Bar in Microsoft Excel is utilized. The dry density of soil specified as the dependent variable and other soil properties such as (LL, PL, PI, ω, TSS, OM, and SO_3) specified as independent variable individually. SLRA models for the

specified soil property are present in Figure (2) to Figure (10) below.

The correlation formulae and the coefficient of determination are presented in Table (3). As shown in Table (4), model 5 has given the closest coefficient of determination to 1while model 9 given the closest coefficient of determination to 0.

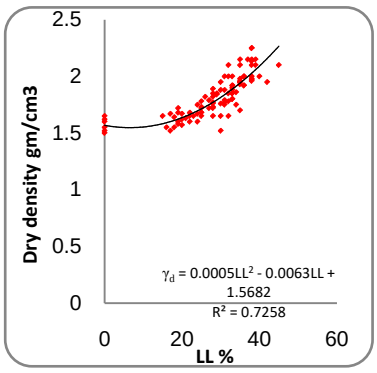


Figure 2: Dry Density vs LL

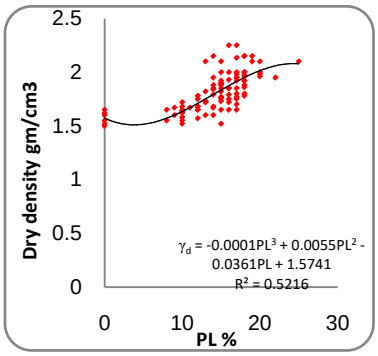


Figure 3: Dry Density vs PL

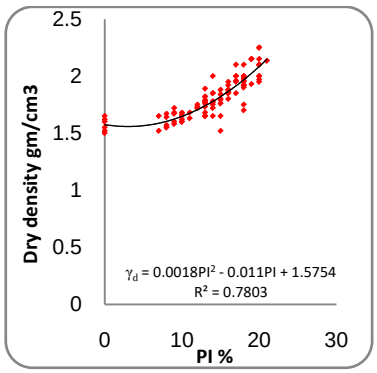


Figure 4: Dry Density vs PI

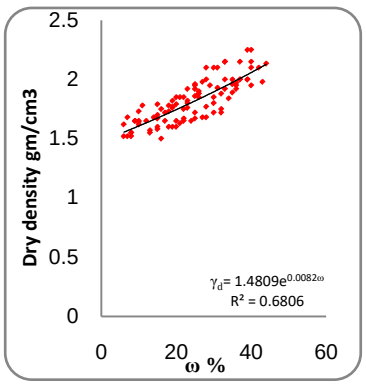


Figure 5: Dry Density vs ω

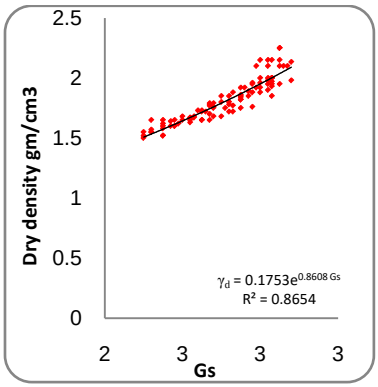


Figure 6: Dry Density vs G_s

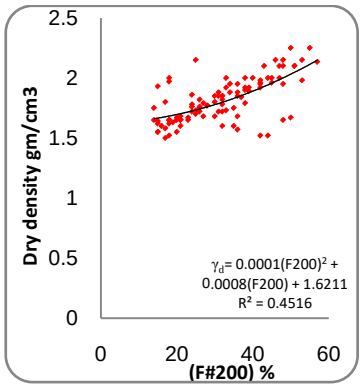


Figure 7: Dry Density vs F# 200

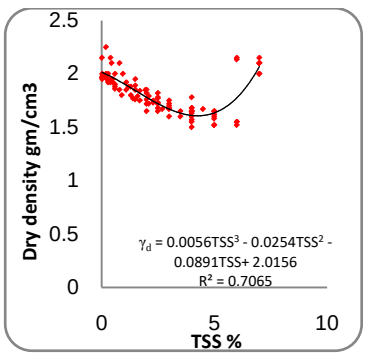


Figure 8: Dry Density vs Tss

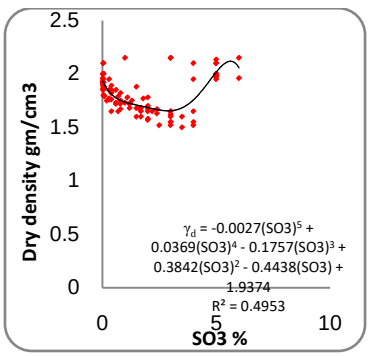


Figure 9: Dry Density vs SO_3

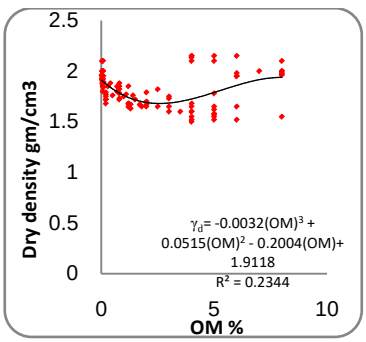


Figure 10: Dry Density vs OM

Table 3: Summary of developed (SRA) to evaluate dry density

SRA	Independent variables	R^2	Developed empirical formulae
Model 1	LL	0.7258	$\gamma d = 0.0005LL^2 - 0.0063LL + 1.5682$
Model 2	PL	0.5216	$\gamma d = -0.0001PL^3 + 0.0055PL^2 - 0.0361PL + 1.5741$
Model 3	PI	0.7803	$\gamma d = 0.0018PI^2 - 0.011PI + 1.5754$
Model 4	Gs	0.8654	$\gamma d = 0.1753e^{0.8608\,Gs}$
Model 5	ω	0.6806	$\gamma d = 1.4809e^{0.0082\,\omega}$
Model 6	$F200$	0.4516	$\gamma d = 0.0001(F200)^2 + 0.0008(F200) + 1.6211$
Model 7	TSS	0.7065	$\gamma d = 0.0056TSS^3 - 0.0254TSS^2 - 0.0891TSS + 2.0156$
Model 8	$SO3$	0.4953	$\gamma d = -0.0027(SO3)^5 + 0.0369(SO3)^4 - 0.1757(SO3)^3 + 0.3842(SO3)^2 - 0.4438(SO3) + 1.9374$
Model 9	OM	0.2344	$\gamma d = -0.0032(OM)^3 + 0.0515(OM)^2 - 0.2004(OM) + 1.9118$

b) Multiple Regression Analysis

To develop the models of multiple regression analysis, dry density value is considered as the dependent variable and physical and chemical soil properties such as (LL, PL, PI, ω, TSS, OM, and SO_3) are considered as independent variables utilized together in developed formula. Six models Table (4) with different soil properties choice from the database to develop the correlation. The statistical parameter as coefficient of determination (R^2) values is calculated. The predicted dry density values are plotted with the actual dry density values provided from database. The best line are drawn to evaluate the variation between the estimated value and the real value. Figure (11) to Figure (14) Explain the variation between real and estimated dry density value.

Table 4: Summary of developed (MRA) to evaluate CBR value

MRA	Independent variables	R^2	Developed empirical formulae
Model 10	LL, PL, PI, ω, Gs, F200, TSS, SO3 and OM	0.92	γd = −0.32331 + 0.090914 LL − 0.0947PL − 0.08925PI + 0.000214 ω + 0.812355Gs + 0.001807F200 − 0.06588TSS + 0.028297SO3 + 0.008072 OM
Model 11	LL, PL, PI, ω, Gs, and F200	0.90	γd = −1.313028295 + 0.095710046LL − 0.09471365PL − 0.092730055PI + 0.001277011 ω + 1.097524369Gs + 0.001872137F200
Model 12	LL, PL, PI, ω, and Gs	0.89	γd = −1.408337645 + 0.106414816 LL − 0.104265638 PL − 0.104753722 PI + 0.002239171 ω + 1.146455612 Gs
Model 13	TSS, SO3, and OM	0.80	γd = 2.042655154 − 0.109336005 TSS + 0.037814019 SO3 − 0.00146424 OM
Model 14	LL, PL, and PI	0.73	γd = 1.445378617+0.112257516 LL − 0.120009326 PL − 0.078119235 PI
Model 15	ω, Gs, and F200	0.84	γd = −1.886748318+0.00075222 ω + 1.328356584 Gs + 0.002640785F200

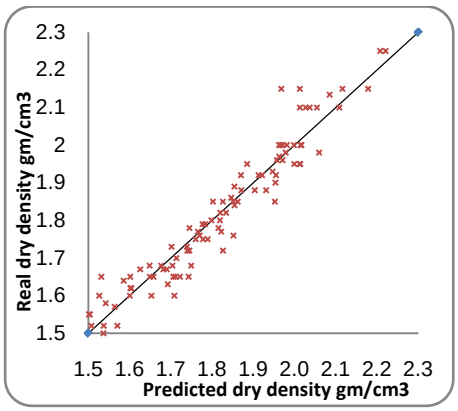


Figure 11: Real VS Predeectied Density for Model 10

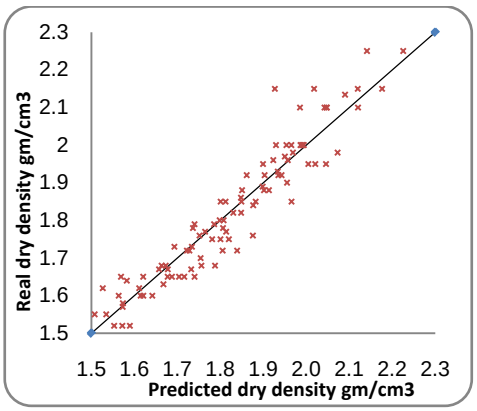


Figure 12: Real VS Predeectied Density for Model 11

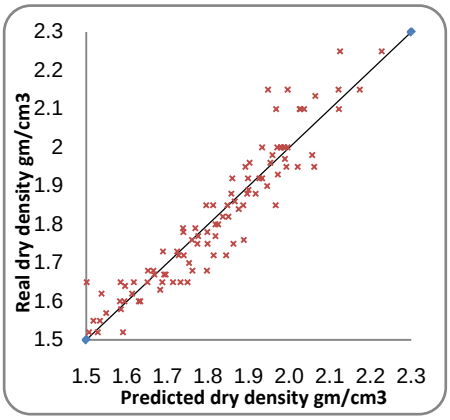


Figure 13: Real VS Predeectied Density for Model 12

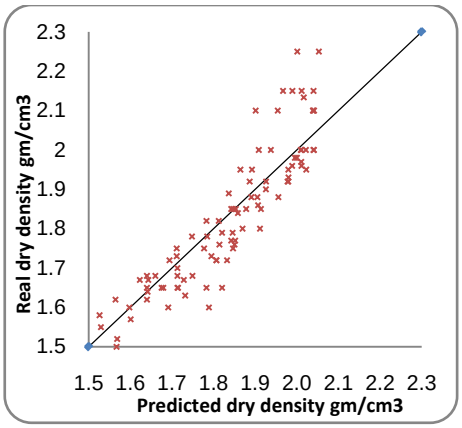


Figure 14: Real VS Predeectied Density for Model 13

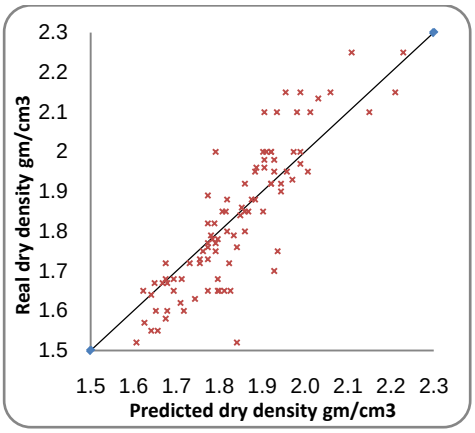


Figure 15: Real VS Predeectied Density for Model 14

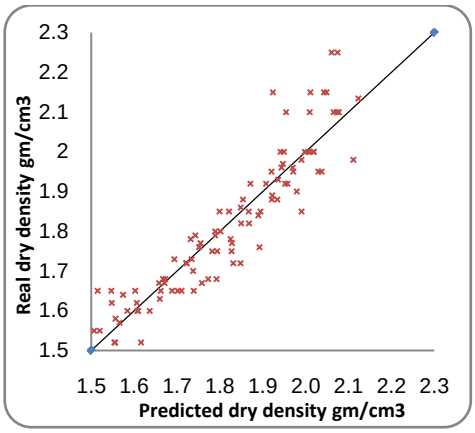


Figure 16: Real VS Predeectied Density for Model 15

IV. Conclusion

Depending on the results of the correlation above, the following points may be concluded:

1. Some soil properties put high coefficient of determination with dry density such as specific gravity and plasticity index while other soil properties put low coefficient of determination such as liquid limit, moisture content, total soluble salts, and plastic limits. This indicating accepted mean, that the soil with higher specific gravity must be higher in dry density.
2. The correlation using more than one soil properties give higher than when using one soil properties.
3. When using effective soil properties in multiple correlation, the coefficient of determination get higher.
4. When increase the samples which are utilized in correlation, the coefficient of determination get higher.

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Analysis of Air Pollution in Ado Ekiti Residential and Commercial Areas

By Awopetu, M. Sanmi & Aribisala, J. Olugbenga
Ekiti State University

Abstract- Air pollution is one of the environmental challenges threatening the wellbeing of man, animals and plants as well as the environment. A number of research works has linked air pollution with adverse health, acid rain, climate change and global warming. This study investigated the level air pollution in Ado Ekiti. The air pollutants investigated includes Particulatematter ($PM_{2.5}$ and PM_{10}), Total suspended particles (TSP), carbon monoxide (CO),Hydrogen sulfide (H_2S), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). The air quality samples were taking in July 2017 (Rainy season) and January 2018 (Dry season) for a period of one week in each season. Seven (7) sampling points across the two (2) major environmental zones in the study area namely; commercial and residential (high income and low income areas) were considered, resulting in forty nine (49) samples, three (3) times daily for each of the seven (7) air pollutant totaling two thousand and fifty eight (2058) samples. It was discovered that most of the air pollutants sampled were disgustingly higher than the World health organization (WHO) standard thereby posing great risk to the public health in particular and the environment in general.

Keywords: *air, pollution, urban, residential, commercial, ado-ekiti.*

GJRE-E Classification: *FOR Code: 090599*

Strictly as per the compliance and regulations of :

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Keywords: air, pollution, urban, residential, commercial, ado-ekiti.

I. Introduction

Harmful chemicals break away from several anthropogenic and natural activities to the environment which may results in adverse effects on human health and the environment. Increased combustion of fossil fuels in the last century is responsible for the progressive change in the atmospheric composition (Marilena Kampa and Elias Castanas, 2008), (Awopetu, 2018), (Masitah Alias, 2017). Considering the fact that Ado Ekiti is characterized with burning of bush and refuse, civil engineering construction activities, commercial activities based on oil (diesel and petrol) run combustion engines, every household owing and daily running generator for power supply, many households use charcoal, woods, sawdust or stoves for cooking and heavy vehicular movement with automobile exhaust. All these activities are potential sources of air pollution in Ado Ekiti, thus the need to assess the air quality and its effects on the environment becomes imperative. The continuous deterioration of air quality in many cities in Nigeria (including Ado-Ekiti) sequel to human activities exerts a major strain on the health and well-being of the dwellers. The environment and health of urban dwellers are greatly impaired by poor quality of air characterized with pollutants such as the following;

a) Particulate Matter ($PM_{2.5}$ and PM_{10})

PM_{10} is particulate matter 10 micrometers or less in diameter, $PM_{2.5}$ is particulate matter 2.5 micrometers or less in diameter. $PM_{2.5}$ is generally described as fine particles. These particles constantly enter the atmosphere from many sources. Natural sources include: soil, bacteria and viruses, fungi, mold and yeast, pollen and salt particles from evaporating sea water. Human sources include: Combustion products from space heating, industrial processes, power generation and motor vehicle use. The components of particulate matter (PM) include finely divided solids or liquids such as dust, fly ash, soot, smoke, aerosols, fumes, mists and condensing vapors that can be suspended in the air for extended periods of time. The smaller the particles, the deeper they can penetrate into the respiratory system and the more hazardous they are to breathe. The $PM_{2.5}$ is more dangerous since they are so small and light, fine particles tend to stay longer in the air than heavier particles.

b) Total suspended particulates (TSP)

Can be referred to as a name given to particles of sizes up to about 50 μm. The larger particles in this class are too big to pass through human noses or throats, and so, they cannot enter lungs. They are often from wind-blown dust and may cause soiling of buildings and clothes. However, TSP samples may also contain the small PM_{10} and $PM_{2.5}$ particles that may enter into human lungs [17,18].

c) Carbon monoxide (CO)

This is a colorless, odorless gas created when a fuel is burned or from incomplete combustion of hydrocarbons in gasoline-powered engines such as generator, this is common especially in developing countries. It is worthy of note that there are reported cases of breathlessness, restlessness and unconsciousness following inhalation of fumes

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produced by an electric generator that was put in a confined area (Afolayan et al, (2014), Seleye-Fubura et at, (2011)). As reported by Aliyu, I. and Ibrahim, Z. F. (2014) was a case of CO poisoning resulted in loss of consciousness as seen in a family of six children who slept in an overcrowded room, polluted with burning charcoal which was meant to generate heat for warmth.

d) Nitrogen Dioxide (NO_2)

A natural source of nitrogen oxides occurs from a lightning stroke. The very high temperature in the vicinity of a lightning bolt causes the gases oxygen and nitrogen in the air to react to form nitric oxide. The nitric oxide very quickly reacts with more oxygen to form nitrogen dioxide. Nitrogen dioxide is part of a group of gaseous air pollutants produced as a result of road traffic and other fossil fuel combustion processes (Debbie et al 2018). Its presence in air contributes to the formation and modification of other air pollutants, such as ozone and particulate matter, and to acid rain. Nitrogen dioxide not only is it an extremely toxic gas with an acrid smell, but its presence in the atmosphere puts it at the root of several environmental problems. At first sight, NO_2 seems similar to CO_2, carbon dioxide. Because 78 percent of the air we breathe is nitrogen gas, many people assume that nitrogen is not harmful. However, nitrogen is safe to breathe only when mixed with the appropriate amount of oxygen. These two gases cannot be detected by the sense of smell. A plethora of outdoor studies have examined the health effects of exposure to outdoor nitrogen dioxide. While there are concerns that some of the associations reported for health effects and outdoor nitrogen dioxide may be explained by co-pollutants, extensive reviews have concluded that respiratory health is associated with nitrogen dioxide exposure, independently of these other exposures (EPA, 2008; WHO 2016)

e) Sulphur Dioxide (SO_2)

Sulfur dioxide (SO_2) belongs to the family of sulfur oxide (SOx) gases. These gases are formed when fuel containing sulfur (mainly coal, gasoline and fuel oil) is burned (e.g., for electricity generation) and during metal smelting and other industrial processes as well as in the oxidation of naturally occurring sulfur gases, as in volcanic eruptions. High concentrations of SO_2 are associated with multiple health and environmental effects. The highest concentrations of SO_2 have been recorded in the vicinity of large industrial facilities. SO_2 emissions are an important environmental issue because they are a major precursor to ambient $PM_{2.5}$ concentrations. Short-term exposure to airborne SO_2 has been associated with various adverse health effects (U.S. EPA, 1994; ATSDR, 1998). Multiple human clinical studies, epidemiological studies, and toxicological studies support a causal relationship between short-term exposure to airborne SO_2 and respiratory morbidity. The observed health effects have included respiratory symptoms, airway inflammation, and increased emergency department visits and hospitalizations for all respiratory causes. Inhaling sulfur dioxide causes irritation to the nose, eyes, throat, and lungs. Typical symptoms include sore throat, runny nose, burning eyes, and cough. Inhaling high levels can cause swollen lungs and difficulty breathing. Skin contact with sulfur dioxide vapor can cause irritation or burns.

f) Hydrogen Sulfide (H_2S)

Is created naturally by decaying organic matter and is released from sewage sludge, liquid manure, and sulfur hot springs. It is formed when Sulfur is removed from petroleum products in the petroleum refining process and is a by-product of paper pulping. Hydrogen Sulfide (H_2S) Hydrogen sulfide is a colorless, flammable, extremely hazardous gas with a "rotten egg" smell. It occurs naturally in crude petroleum and natural gas, and can be produced by the breakdown of organic matter and human/ animal wastes (e.g., sewage). H_2S can cause possible life-threatening situations if not properly handled. In addition, hydrogen sulfide gas burns and produces other toxic vapors and gases, such as sulfur dioxide.

Therefore, there is a need to carry out investigation on quality of air in Ado-Ekiti in order to scientifically establish the quality. This research work will provide a baseline data on air pollutants and level of air pollution in a typical Nigerian city.

II. Research Settings

Ado Ekiti is a city in southwest Nigeria, the state capital and headquarters of the Ekiti State. It is also known as Ado. It has a population of above 424, 340. The people of Ado Ekiti are mainly of the Ekiti sub-ethnic group of the Yoruba. Ado Ekiti has four tertiary educational institutions namely: Ekiti State University, Afe Babalola University and The Federal Polytechnic Ado Ekiti and Ekiti State School of Nursing and Midwifery. It also play host to two local television and three radio stations; NTA Ado Ekiti, Ekiti State Television (ESBS), Ekiti FM, Voice FM and Progress FM Ado Ekiti. Various commercial banks and enterprises operate in Ado Ekiti. Ado Ekiti also have ninety four (94) hotels and more that fifty (50) petrol stations all running on generating sets as source of electricity between two to twenty four hours per day.

The town lies between the latitude 7^0 33^1 and 7^0 42^1 North of the equator and the longitude 5^0 11^1 and 5^0 20^1 East on a low-land surrounded by several isolated hills and inselbergs, [4]. Geologically, the region lies entirely within the pre-Cambrian basement complex rock group, which underlies much of Ekiti State [5]. The temperature of this area is almost uniform throughout the year; with little deviation from the mean annual temperature of 27^0 C. February and March are the hottest 28^0 C and 29^0 C respectively, while June with

temperature of 25^{0}C is the coolest [6]. The mean annual rainfall is 1,367mm with a low co-efficient variation of about 10% and 117 raining days in year 2017. Rainfall is highly seasonal with well marked wet and dry season. The wet season lasts from April to October, with a break in August.

III. Research Method

a) Sampling

Air sampling collection and analysis is required in order to quantify the air pollutants in the study area. To obtain valid data considering the fact that measuring air pollution is a complex task and requires due care and diligence, the following issues were put into consideration: (i) Appropriateness of the sample points; (ii) How representative will the sample be in time and space; and (iii) How appropriate is the sampling equipment, analysis and calibration techniques.

Hand held portable Aeroqual series 500 ambient air quality sampling equipment was used to measure $PM_{2.5}$, PM_{10}, TSP, CO, H_2S, NO_2, and SO_2. The air quality sample was taking in July 2017 (Rainy season) and January 2018 (Dry season) for a period of one week in each season. All sampling locations were sampled at different times of the day (morning, afternoon and evening). Morning readings were taken between 8am-11am, afternoon readings between 12pm-3pm and evening readings were taken between 4pm-7pm.

Seven sampling points for seven days across two environmental zones in the study area namely; commercial and residential (high income and low income areas) were considered, resulting in 49 samples for each of the seven air pollutants totaling 2058 samples. Air monitoring was carried out in seven core sites which are as follows:

i. Old garage: (this is characterized by retail shops, market, high vehicle and pedestrian traffic, it also serves as transfer point for mini buses and taxi linking other towns, urban, peri-urban and rural destinations);
ii. GRA: (represented high economic status residential area with low vehicular and pedestrian traffic volume);
iii. Ajilosun: (represented medium economic status residential area where majority of the residents either use kerosene or cooking gas for cooking);
iv. Dalimore Junction: (this serves as an important commuter route within ado Ekiti which represented heavy-traffic sites);
v. Odo Ado: Odo Ado-Ekiti (represent rural background area);
vi. Fajuyi Park: (represented civil engineering construction activity area); and
vii. Ilokun: (represented low economic status residential area where the houses are built of mud bricks without plastering and the floors were not paved or cemented. A lots of fire wood burning activities were taking place).

IV. Results and Discussion

Ado Ekiti is a typical town in Nigeria, it is a civil or public servant dominated areas with a lots of commercial activities without a single industrial activity. Table: 1 – 17 show daily average air pollution level raining season (Table: 1, 3, 5, 7, 9, 11 and 13) and dry season (Table: 2, 4, 6, 8, 10 and 14). The results showed that air pollution level is generally higher in dry season than that of the raining season. The WHO standard for $PM_{2.5}$ and PM_{10} are 25 $\mu g/m^3$ and 150 $\mu g/m^3$ respectively, the least $PM_{2.5}$ was 17.5 $\mu g/m^3$ in GRA (Table 3) while the highest 137.6 $\mu g/m^3$ was recorded in Old garage (Table 2). On the contrary, the least PM_{10} was 44.7 $\mu g/m^3$ in Ilokun (Table 14) while the highest 1036.9 $\mu g/m^3$ was recorded in Old garage (Table 2). The $PM_{2.5}$ and PM_{10} concentrations were higher in dry season. This was similar to the study conducted Zirui Liu et al (2004). In a similar study conducted by Ngele et al (2015), PM10 concentration in Motor Park fell between 32 and 58 $\mu g/m^3$ which was lower than the results obtained in motor park area of the current study area. It was observed that GRA and Ilokun had $PM_{2.5}$ and PM_{10} that meet the WHO ambient air quality standard.

The raining season highest daily average of TSP concentration 2202.1 $\mu g/m^3$ was recorded at Fajuyi (Table 12) while the lowest (63.8 $\mu g/m^3$) was recorded in Ilokun. Further, the dry season highest daily average of TSP concentration (1400 $\mu g/m^3$) was recorded at Old garage (Table 2) while the lowest (74.6 $\mu g/m^3$) was recorded in Ilokun. It is disheartening to note that the TSP concentration exceeds the WHO standards. This much higher than the 250 μgm^3 maximum daily average TSP sets by the national environmental pollution regulatory body, Federal Environmental Protection Agency. In a similar study conducted by Sana'a Abed El-Raoof Odat (2009), the highest monthly average TSP in May ranged between 108 - 455 $\mu g/m^3$ and the lowest found in March ranged between 56 – 352 $\mu g/m^3$ and this concentration also exceed WHO standards. According to the data collected, it is possible to assert that the construction site activities at Fajuyi influenced the environment through a higher emission of TSP during the studied period.

It was observed that the CO pollutant measured was relatively higher than 10ppm FEPA (Nigerian) standard. The entire CO measured during dry and raining seasons in GRA and Ilokun fell between 0.8 – 9.23 ppm and 0.03 – 1.40 ppm respectively which is lower than Nigeria standard [Federal Environmental protection Agency of Nigeria (FEPA)]. Limits set also by FEPA are CO - 10ppm, SO_2 - 0.01ppm, NO_2 - 0.04-0.06ppm. It was also observed that most of CO air

pollution measured at Old garage, Dalimore, Odo - Ado, Fajuyi and Ajilosun were higher than the Nigerian standard with Old garage recorded the worst CO pollutant concentration (2.2 – 30.5 ppm). CO has affinity to interferes with the blood's ability to carry oxygen to the body's tissues and results in numerous adverse health effects. The high value of CO observed at Old garage could be attributable to high vehicular movement in and around the area. In a similar study carried out by Abam and Unachukwu, (2009) in Calabar, Nigeria, the CO concentration ranged between 4.4 – 8.7ppm which was lower than the Nigerian standard, while Augustine C. (2012) recorded CO between 0.00 and 13. 0 ppm in a study carried out in Port Harcourt, Nigeria

The H_2S, NO_2, and SO_2 pollutant measured in the study area ranged between 0.03 – 1.23ppm, 0.055 – 0.057ppm and 0.01 – 1.30 ppm respectively. It was observed that the SO_2 concentration was higher than the Nigerian standard while the NO_2 concentration fell within the range specified by the Nigerian regulating body. In a similar study conducted by Koku and Osuntogun, (2007) in Ado - Ekiti, the highest level obtained were NO_2 - 0.6 ppm at Ijigbo Junction and SO_2 - 0.8ppm at Old garage junction. The obtained results of SO_2 and NO_2, were found to be higher than FEPA limits.

Table 1: Daily average raining season Air quality sample reading taken at Old garage

Daily average	$PM_{2.5}\mu g/m^3$	$PM_{10}\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	60.6	706.0	1297.2	11.8	0.50	0.056	1.00
Tue	70.1	755.0	922.1	15.4	0.20	0.055	0.90
Wed	32.6	142.4	521.0	10.5	0.10	0.057	0.20
Thu	75.2	691.2	1269.6	13.7	0.40	0.055	1.30
Fri	30.2	394.1	734.2	11.9	0.20	0.056	0.80
Sat	41.0	188.8	368.8	2.2	0.20	0.057	0.10
Sun	57.4	426.5	706.1	30.5	0.40	0.056	0.30

Table 2: Daily average dry season Air quality sample reading taken at Old garage

Daily average	$PM_{2.5}\mu g/m^3$	$PM_{10}\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	92.3	826.3	1221.4	14.5	0.50	0.057	1.30
Tue	94.0	846.8	1400.1	16.2	0.50	0.056	1.20
Wed	75.1	1036.9	825.2	12.7	0.30	0.057	1.00
Thu	115.5	824.4	1191.4	16.1	0.60	0.057	1.10
Fri	137.6	558.2	1232.4	12.9	0.60	0.057	0.90
Sat	77.9	644.9	489.4	8.5	0.40	0.057	1.30
Sun	109.4	611.4	908.5	20.3	0.70	0.056	1.00

Table 3: Daily average dry season Air quality sample reading taken at GRA

Daily average	$PM_{2.5}\mu g/m^3$	$PM_{10}\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	19.4	48.8	67.0	2.03	0.11	0.056	0.07
Tue	18.4	49.2	64.9	0.80	0.05	0.056	0.07
Wed	19.6	48.5	65.2	1.50	0.09	0.056	0.15
Thu	23.7	48.5	69.0	1.03	0.05	0.056	0.17
Fri	23.0	66.4	109.9	1.73	0.05	0.056	0.17
Sat	20.6	58.0	105.7	1.03	0.03	0.056	0.07
Sun	17.1	52.5	90.0	1.57	0.04	0.056	0.01

Table 4: Daily average dry season Air quality sample reading taken at GRA

Daily average	$PM_{2.5}\mu g/m^3$	$PM_{10}\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	21.4	57.77	85.3	4.90	0.83	0.057	0.41
Tue	18.9	64.7	76.5	4.33	0.70	0.057	0.71
Wed	17.2	55.4	80.8	3.30	0.96	0.057	0.46
Thu	16.3	75.5	83.6	2.07	1.03	0.055	0.55
Fri	16.7	55.6	79.0	3.73	0.76	0.057	0.66
Sat	18.6	82.1	87.1	2.17	0.60	0.056	0.48
Sun	13.8	71.5	79.3	9.23	1.01	0.056	0.65

Table 5: Daily average raining season Air quality sample reading taken at Ajilosun

Daily average	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	32.7	209.0	387.3	2.50	0.12	0.056	0.11
Tue	33.7	202.7	405.9	3.23	0.18	0.056	0.07
Wed	34.2	225.6	356.8	3.07	0.17	0.056	0.07
Thu	31.1	248.3	328.7	6.24	0.14	0.055	0.06
Fri	26.6	219.2	274.7	5.94	0.08	0.056	0.16
Sat	26.9	142.5	217.3	7.13	0.21	0.056	0.18
Sun	21.7	64.9	96.5	5.93	0.17	0.057	0.14

Table 6: Daily average dry season Air quality sample reading taken at Ajilosun

Daily average	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	43.3	297.9	346.4	5.10	0.12	0.057	0.44
Tue	43.7	331.9	319.7	5.73	0.14	0.057	0.50
Wed	28.8	102.8	305.7	10.83	0.31	0.057	0.55
Thu	42.6	318.8	403.4	15.20	0.25	0.056	0.08
Fri	35.4	229.6	295.0	11.10	0.17	0.056	1.18
Sat	45.9	316.1	437.6	6.27	0.14	0.057	0.25
Sun	109.7	231.6	277.5	10.87	0.09	0.056	0.40

Table 7: Daily average raining season Air quality sample reading taken at Odo Ado

Daily average	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	30.7	127.7	201.8	10.67	0.11	0.056	0.15
Tue	32.3	149.5	215.5	9.37	0.08	0.056	0.18
Wed	52.4	272.9	275.0	6.70	0.06	0.055	0.12
Thu	75.5	340.7	298.5	5.80	0.09	0.055	0.09
Fri	71.3	320.8	293.4	9.00	0.07	0.055	0.05
Sat	45.7	466.1	679.7	8.43	0.20	0.055	0.14
Sun	23.3	436.3	702.0	10.43	0.28	0.055	0.13

Table 8: Daily average dry season Air quality sample reading taken at Odo Ado

Daily average	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	40.6	121.8	274.3	13.77	0.11	0.056	0.91
Tue	54.4	391.4	371.4	12.36	0.09	0.055	0.45
Wed	49.3	354.6	431.7	12.17	0.28	0.055	1.16
Thu	43.5	379.7	428.4	14.77	0.08	0.056	0.81
Fri	41.9	343.6	488.2	17.33	0.18	0.056	0.56
Sat	59.8	426.4	488.8	17.17	0.25	0.056	0.83
Sun	65.8	138.8	131.2	12.13	0.17	0.056	0.78

Table 9: Daily average raining season Air quality sample reading taken at Dalimore

Daily average	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	51.0	189.7	229.5	8.37	0.18	0.056	0.02
Tue	49.5	197.7	293.1	10.03	0.19	0.056	0.08
Wed	46.1	187.0	426.8	10.07	0.24	0.055	0.18
Thu	48.8	173.8	534.9	12.03	0.20	0.055	0.20
Fri	43.7	136.3	428.0	13.97	0.17	0.055	0.21
Sat	39.9	127.7	297.5	15.57	0.13	0.056	0.19
Sun	30.8	87.3	154.0	15.27	0.16	0.056	0.30

Table 10: Daily average dry season Air quality sample reading taken at Dalimore

Daily average	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	58.2	234.3	308.4	12.70	0.35	0.056	0.77
Tue	61.3	226.1	459.9	12.30	0.34	0.056	0.70
Wed	53.4	162.0	881.4	17.30	0.43	0.057	1.16
Thu	63.3	296.0	316.2	14.13	0.37	0.056	0.80
Fri	60.8	360.5	449.6	9.07	0.29	0.056	0.75
Sat	65.8	359.6	455.0	12.47	0.34	0.056	0.36
Sun	69.4	261.7	233.1	11.80	0.31	0.056	0.66

Table 11: Daily average raining season Air quality sample reading taken at Fajuyi

Daily average	$PM_{2.5}\mu g/m^3$	$PM_{10}\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	60.7	1083.3	1978.5	7.26	0.19	0.056	0.08
Tue	61.2	1082.7	1974.4	9.23	0.24	0.056	0.09
Wed	51.2	626.7	754.2	10.00	0.24	0.055	0.06
Thu	57.3	551.9	585.4	10.13	0.20	0.055	0.07
Fri	56.3	727.6	949.9	11.07	0.13	0.055	0.08
Sat	52.3	560.7	1452.9	10.73	0.16	0.055	0.05
Sun	43.2	604.4	2202.1	13.23	0.25	0.056	0.14

Table 12: Daily average dry season Air quality sample reading taken at Fajuyi

Daily average	$PM_{2.5}\ \mu g/m^3$	$PM_{10}\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	59.4	725.1	926.4	7.26	0.19	0.057	0.55
Tue	58.6	467.5	316.2	10.13	0.20	0.056	0.07
Wed	42.6	515.5	404.9	13.23	0.25	0.057	0.14
Thu	59.9	717.9	308.4	9.23	0.17	0.056	0.26
Fri	65.2	598.4	436.5	11.07	0.29	0.056	0.29
Sat	60.1	883.8	455.1	16.43	0.17	0.057	0.12
Sun	55.8	258.4	180.5	11.17	0.03	0.057	0.72

Table 13: Daily average raining season Air quality sample reading taken at Ilokun

Daily average	$PM_{2.5}\ \mu g/m^3$	$PM_{10}\ \mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	23.6	74.8	92.4	0.30	0.09	0.055	0.60
Tue	22.9	67.0	95.0	0.33	0.13	0.056	1.04
Wed	22.0	65.8	89.5	0.08	0.06	0.056	1.01
Thu	24.4	68.3	84.8	0.10	0.06	0.056	0.95
Fri	19.8	62.1	66.7	0.08	0.02	0.056	0.51
Sat	20.9	51.4	63.8	0.78	0.04	0.056	0.51
Sun	23.7	48.5	69.0	1.03	0.05	0.056	0.17

Table 14: Daily average dry season Air quality sample reading taken at Ilokun

Daily average	$PM_{2.5}\mu g/m^3$	$PM_{10}\mu g/m^3$	TSP ppm	CO ppm	H_2S ppm	NO_2 ppm	SO_2 ppm
Mon	30.4	77.8	100.3	0.49	0.09	0.056	1.13
Tue	24.6	63.9	116.7	0.43	0.06	0.056	1.10
Wed	26.7	49.3	99.1	0.74	0.05	0.057	0.71
Thu	30.5	60.5	78.5	1.40	0.62	0.057	1.29
Fri	23.5	44.7	87.2	0.03	0.51	0.056	0.62
Sat	24.6	58.3	74.6	0.96	0.41	0.056	0.64
Sun	44.4	79.7	89.7	0.77	1.23	0.057	0.47

V. Conclusions and Recommendations

Obviously, air pollution is something we cannot overlook in our generation; the adverse effect is already evident. Man remain passive and aloof to air pollution mitigation will definitely spell doom for human, plant, animal and the environment. The study area (Ado Ekiti) is grossly polluted as manifest by the results in the Tables 1 – 14. It is disheartening to note that the state and local government had no air quality maintenance scheme. Absolutely there is no policy formulation towards air quality mitigation or control. It is also pertinent to note that apart from data collected by a small number of individuals and corporate organizations at spread locations, there is no all-inclusive and pragmatic database on the enormity of the peril and its injurious effects on the ecosystems and people in the area. Taking into consideration, the causes of air pollution and its adverse effects, each person is responsible for all the causes of air pollution and the polluted environment that we dwell in today.

It is recommended that:

i. There is a need to develop monitoring mechanisms, regulations and enforcement measures;
ii. The current internal generation revenue (IGR) driven motor vehicles annual testing and other regulations such as electrical generators should be reoriented and tailored towards environmental mitigation driven;
iii. There should be a consideration on the reduction of pollution levels from vehicles and domestic burning of woods and charcoal, to permissible levels as defined in national and international standards;

iv. The impact of air pollution from commercial, domestic and vehicular sources on the health of the residents in the study area needs to be researched in-depth; and
v. There is a need to engage in renewable energy, clean energy and cleaner air initiatives

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The following benefitscan be availed by you only for next three years from the date of certification.

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As MARSE, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSE member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSE, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

AUXILIARY MEMBERSHIPS

Institutional Fellow of Open Association of Research Society (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

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We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

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Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

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2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
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6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

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Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

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- Findings
- Writings
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- Illustrations
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- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

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2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

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The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

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Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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