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Editorial

INFORMATION TECHNOLOGY: A Necessity

*Information technology is the technology used to store, control, disseminate or make data. All these can be summed up effectively – It's having learning, and learning originates from having information. Gaining knowledge through information is the role of "**information technology**" IT in today's educated world. IT is a set of tools that can help provide the right people with the right information at the right time. Though IT is not a solution to everything, for IT to work, people must learn how to use it. So, you cannot assume that IT will work for you to share information across the organization when people in the organization don't know how to use it. The present society is diverse to the one that existed not all that numerous years back. Our society is constantly evolving. The most imperative qualities of our time might be the change, transmission, and domain of information. We live in an information society where the main part has been given to new advances, particularly those committed to an information. Our society couldn't be envisioned without new innovations and their part both in this society and in human life when all is said in done. Current innovation has changed individuals' communication tool.*

Technology is building spans between individuals on inverse sides of the globe, bringing individuals from all societies and foundations into contact with each other. The Internet has a colossal information. Technology has made it workable for this data to reach far and wide. IT assumes an essential part in every one of the segments for instance education, banking, insurance, transport, communication, and so forth. In this quicker and present-day world, Education is an unavoidable fragment. Online education has set in, making it conceivable to render learning to students occupying remote areas on Earth. The new part of data innovation is Online tuition educating. Change of IT makes another route for the students for new creations. It is because of the World Wide Web that the information could achieve every last one over the computer networks. Likewise, current innovation has additionally given approaches to develop more sustenance, transport more individuals and make more items for a developing society. Computerization of procedures has realized productivity and speed. Expedient execution of assignments has spared human exertion and time. Yet, in my opinion, new advances in some cases are influencing individuals to dull. Because of reliance on innovation for each errand. So, we require advances, since they are making our lives more agreeable and security, yet how about we not make innovations our propensity. To conclude, if we use the IT in a proper way, we can say that information technology plays an effective role.

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Influence of Structural Parameters on the Fundamental Time Period of Multistoried Regular RC Building Frames

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Abstract:

Ethiopian Building Code Standards, Part 8 (EBCS-8) express the fundamental time period(T_1) approximately as a function of the building height (H) only($T_1 = C_1 H^{3/4}$), thus to verify the level of appropriateness, an extensive study was conducted to identify the important structural parameters and their influence on the fundamental time period of regular multistory RC building frames for earthquake resistant design.

Data were gathered and selected model frames were analyzed by modal analysis technique using computer software SAP 2000 v14 and Rayleigh's formula. Periods of model frames were plotted against respective parameters.

This study have identified the important building frame parameters that govern the earthquake response of a regular building frame structure, and thus appreciated the influence of structural parameters on fundamental time period of regular reinforced concrete moment resisting multistoried building frames by providing an improved alternative empirical relation.

Key Words: Fundamental Time Period, EBCS-8, Rayleigh's Method, Equivalent Static Analysis, Modal Analysis, Earthquake Resistant Design, Base Shear, Structural Parameters, Regular Moment Resisting Building Frames.

1. Introduction

1.1 Background

Building frames are the most widely used structural systems in construction practice. Seismic codes including EBCS-8 suggest *Equivalent Static Method* for earthquake resistant design.

This method suggest a simplified equivalent static approach for the calculation of base shear and its distribution as earthquake forces over the height of the building frame [1]. In this approach, to calculate the fundamental time period (T_1)for regular frames up to 80m height, the code provides an approximate formula $\left(T_1 = C_1 H^{\frac{3}{4}}\right)$in terms of building height. Then this fundamental time period is used for the determination of the base shear. Thus the base shear obtained by using the formula ($T_1 = C_1 H^{3/4}$) is of conservative nature.

1.2 Problem Statement

Lack of consideration of other structural parameters makes this code formula wholly approximate. According to modal analysis technique, however, frequency and hence time period of a structure are functions of its stiffness and mass [2]. It is anticipated, therefore, the fundamental time period of the structure would be influenced in addition to height by the width and number of bays, size of columns and beams, strength and density of concrete of frames, as these would affect the stiffness and mass.

Thus the intention of this study is to bring, the effect of structural parameters into attention since using the approximate formula leads to an under/over estimation of the earthquake forces. If it's underestimated it will eventually lead to an unexpected structural failure, caused by inadequate provision of section dimensions of structural elements, endangering the livelihood of the occupants and loss of property in the building and if it's overestimated it will cause a huge impact on economy due to exaggerations in providing section dimensions of structural elements.

1.3 Objectives

A detailed literature review was carried to define the objectives. Next chapter is giving the in-depth details of literature review carryout for this thesis work.

1.3.1 General Objective

Broadly the objective of this study is to examine the influence of different structural parameters on fundamental time period of regular RC building frames for earthquake resistant design. Particularly the followings were the specific objectives

1.3.2 Specific Objectives

1. To compare the fundamental time period by approximate formula and the modal analysis.
2. To outline the possible implications of the effects of the parameters on period in light of Earthquake resistant design.
3. To come up with a new empirical formula comprising of the investigated parameters

The following research questions were addressed in the study.

1.4 Significance

Apart from the researcher's personal interest and detail self-acquaintance on the subject matter the thesis work will be useful in the following aspects

(i) To bring into attention the effect of structural parameters, other than building height, on fundamental period.
(ii) To reduce the under/over estimation of the earthquake forces, that arise from using the approximate formulae suggested in EBCS-8, which have a great role in determining economy and structural safety or wellbeing of occupants during such natural hazards.
(iii) To incorporate the effects of structural parameters on earthquake resistant designs which otherwise could be taken as conservative by providing the necessary design data (empirical formula).
(iv) To encourage other researchers to pursue further study in this area.

1.5 Scope

(i) The present study is limited to reinforced concrete (RC) regular and symmetric multi-storied moment resisting building frames.
(ii) Infill stiffness is not considered in the present study. However, associated mass and weight is assumed in the analysis.
(iii) Moment resisting building frames from 3storeys to20storeys with different variations of system parameters are considered.
(iv) Soil-structure interaction effects are not considered in the present study.
(v) Column ends are assumed to be fixed at the foundation.

1.6 Origin of the Code Formula

The magnitude of the mass and the stiffness of the structure are not separable, and do affect simultaneously the response to ground motion. However, because the structure is subjected to a base motion and not to a force, the maximum stress that the structure experiences is a function of its stiffness as well as of its period of vibration. But for ease of

calculation codes suggest approximate formulae for the base shear force and period. [1].
Base Shear and period by EBCS-8
According to EBCS-8 base shear $F_b$is given by;

$$F_b = S_d (T_1) W \quad (1)$$

Where, $S_d(T_1)$ Ordinate of the design spectrum at period T_1
T_1 Fundamental period of the structure for translational motion in the direction Considered.
W Seismic dead load

For buildings with heights up to 80m, T_1 can be approximated using the following formula

$$T_1 = C_1 H^{3/4} \quad (2)$$

Where, T_1 fundamental period of buildings in seconds
H height of the base above the building in meters
C_1 =0.075 for RC moment resisting frames

Eq. (2), which was appeared first time in the ATC3-06 (Applied Technological Council, 1978) report, was derived using Rayleigh's method (Chopra 1995) with the following assumptions: (i) Equivalent static lateral forces are distributed linearly over the height of the building; (ii) seismic base shear is proportional to $1/T^{2/3}$; and (iii) deflections of the building are controlled by drift limitations. Although the first two assumptions are evident, the third assumption implies that the height wise distribution of stiffness is such that the inter-story drift under linearly distributed forces is uniform over the height of the building [9].

Rayleigh's Method is based on the principle of conservation of energy which was published in 1873 developed by Lord Rayleigh. The maximum potential energy of the system over a vibration cycle is equal to its strain energy associated with the maximum displacements and the maximum kinetic energy of the system over a vibration cycle is associated with the maximum velocities. The principle of conservation of energy states that the total energy in a freely vibrating system without damping is constant (i.e. it doesn't vary with time) thus the two energies must be equal which obtains the natural vibration frequency. The accuracy of the natural vibration frequency estimated using Rayleigh's method depends entirely on the shape function that is assumed to approximate the exact mode shape. In principle any shape may be selected that satisfies the displacement boundary conditions.

For a multistory building frame the natural frequency, using Rayleigh's method, can be calculated using the formula

$\omega_n^2 = \frac{\sum f_i \delta_i}{\sum m_i \delta_i^2}$Where f_i,m_i&δ_i are the lateral force, mass and deflection for i^{th} story

The success of Rayleigh's method for estimating the fundamental natural frequency of a structure depends on the ability to visualize the corresponding natural mode of vibration that the shape function is intended to approximate, However the mode shape of more complex systems may not be easy to visualize, and even a shape function calculated from static deflections due to self-weight of the structure may not be appropriate [10].

Moreover Rayleigh's formula for the computation of fundamental period T (in second) is given by:

$$T = 2\pi \sqrt{\frac{\sum w_i \, \delta_i{}^2}{g \sum f_i \, \delta_i}}$$

w_i-the portion of the total seismic dead load located at or assigned to level i

δ_i –the horizontal relative displacement at level i due to applied lateral forces

f_i- the lateral force at level i and

g- Acceleration due to gravity.

The code specifies that the fundamental period may be determined through an alternative substantiated analysis such as normal mode analysis or Rayleigh's method, both of which require the use of a computer program which make the determination of the fundamental period cumbersome for most practicing engineers.

Therefore the fundamental vibration period of a building which appears in the equation specified in building codes, adopted from ATC3-06 report 1978, to calculate the design base shear and lateral forces is provided from empirical relationships based on regression analysis. Because this building property cannot be computed for a structure that is yet to be designed, building codes provide empirical formulae that depend on the building material [steel, reinforced concrete (RC), etc.], building type (frame, shear wall, etc.), and overall dimensions calculated using regression analysis based on periods of buildings "measured" from their motions recorded during the 1971 San Fernando earthquake.

The authors of ATC-3 realized the Tentative Provisions include many innovations and thus need careful assessment. Thus the preface states [8]:

Consequently the salient objective of this research is to assess the influence of other structural parameters on fundamental period other than building height suggested in the code.

2. Methodology

2.1 Introduction

The study in this paper is based on analysis of a number of structural models representing regular multistoried MRF buildings. These models are analyzed using computer software SAP 2000 v14. The first part of this chapter presents the various considerations and assumptions related with the modeling of the structural members and the frame at large. The next part deals with the study area and source of data used in the study together with the values of the parameters under investigation.

The last part of this chapter presents a brief outline on the modal analysis technique for better understanding of the results.

2.2 Modeling

Modeling a building comprises of demonstrating and grouping of its various load-carrying elements. The model must ideally represent the mass distribution, strength, stiffness and deformability characteristics of the building under consideration. Modeling of the material properties and structural elements used in the present study is discussed below.

2.2.1Material Properties

C-25 grade of concrete and S-300 grade of reinforcing steel are used for all the frame models used in this study. Elastic material properties of these materials are taken as per EBCS-2 1995 clause 2.5.2.

2.2.2 Structural Elements

Beams and columns are modeled by 2D frame elements. The beam-column joints are

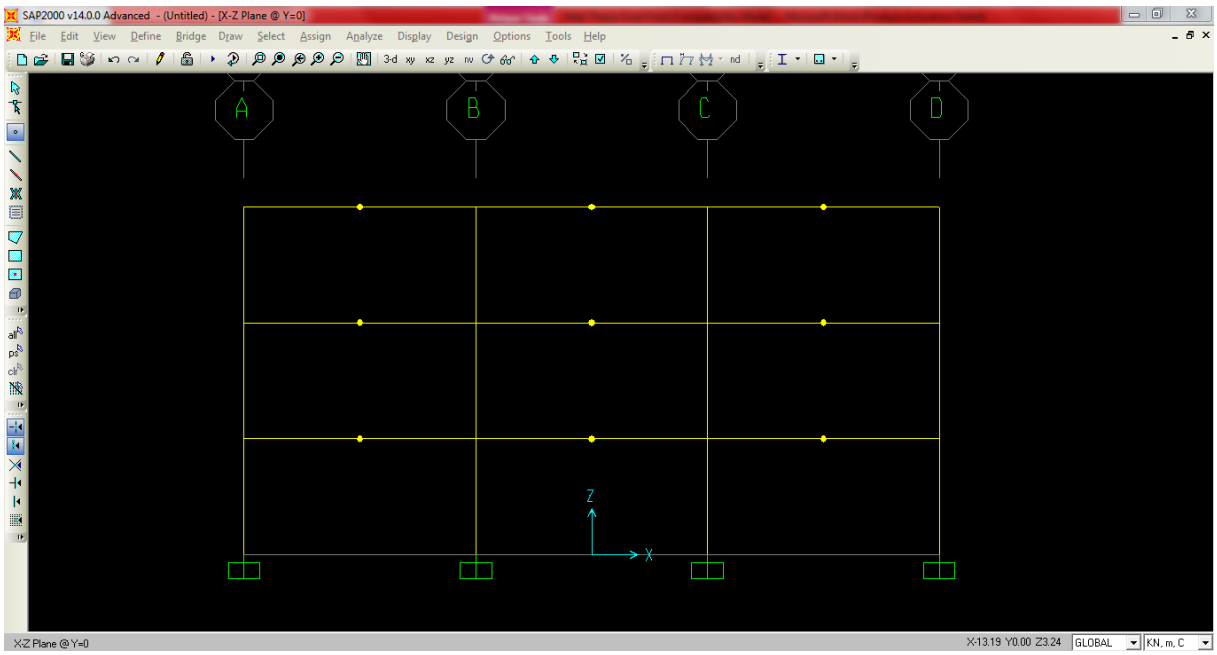
assumed to be rigid and the column end at foundation was considered as fixed for all the models in this study.

The structural effect of slabs due to their in-plane stiffness is taken into account by assigning 'diaphragm' action at each floor level. The mass/weight contribution of slab is modeled separately on the supporting beams. Infill stiffness is not considered in the present study. However, associated mass and weight is assumed in the analysis.

Lumped mass idealization is exercised in the present study, in which the masses of the floor, beam, column and additional masses of a single bay are lumped (discredited) at the center of the beam of that bay.

The choice of this particular idealization owes the fact that the dynamic analysis of a consistent- mass system requires considerably more computational effort than does a lumped mass idealization, for two reasons (Chopra 1995) : (1) The lumped mass matrix is diagonal, whereas the consistent mass matrix has off-diagonal terms; and (2) the rotational DOF can be eliminated by static condensation from the equations of motion for a lumped mass system, whereas all DOFs must be retained in a consistent mass system. Hence lumped mass idealization is the feasible approach to multistory dynamic analysis of buildings.

Figure 1: Illustration of a Lumped mass idealization of a 3 story 3 bay model frame on SAP 2000v14.



A two dimensional dynamic analysis of the models is carried out using SAP 2000 v14 in this study. For a building that is regular and essentially symmetrical, a 2D model is generally sufficient. When there is irregularity in plan the eccentricity between the center of mass and center of stiffness is large, in which torsion response may be predominant, thus requiring a 3D analysis in an otherwise symmetrical and regular building.

2.3 Selected Parameters

The study is based on two dimensional RC building frames with varying heights and widths. Different building frame geometries were taken for the study. The parameters chosen in this study were taken from different literatures discussed in chapter 2 of this paper. They are listed as follows;

l –Beam Span (m) **s** – Number of Stories

h– Column Height (m) **p** – Number of Bays $\mathbf{m_s}$ – Story Mass (Kg)

All of the parameters listed above are related to the stiffness and mass characteristics of the building, they can also be categorized as member and cross-sectional properties. The values or data under each parameter are determined by two basic data collection methods, namely primary and secondary data collection methods.

Primarily data have been collected through direct observation and structured questionnaire (see Appendix) prepared and aim to collect the real life input data from the design practice. Several consultancy firms and individual design professionals around Mekelle and Adigrat towns (Ethiopia) have responded upon request. Values for maximum, minimum and most common design provisions of each parameter have been gathered.

Summary of Questionnaire Survey:-

Table i: Summary of Questionnaire Survey

Si.No	PARAMETER	RANGE	COMMON VALUES
1	length (m)	3-7	5
2	Height (m)	2.6-5	3
3	Panel	2-10	4
4	storey	2-11	5
5	Column Size(mm)*	350 x 350to700 x 700	400 x 400
6	Beam Size(mm)	250 x 400	250 x 400

*The values for this parameter are story dependent

The Variations in values of each parameter considered is presented below, altogether there are around 200 model frames which have been analyzed with SAP 2000 v14.

Table ii: Parameters and their cases considered for investigation.

PARAMETER	Value 1	Value 2	Value 3	Value 4	Value 5
l –Beam Span (m)	3	4	5	6	7
h –Column Height (m)	2.6	3	3.5	4	5
s – Number of Stories	3	5	10	15	20

Table iii: Cases considered for investigating effect of story mass.

PARAMETER	3 Stories	5 Stories	10 Stories	15 Stories	20 Stories
$\mathbf{m_s}$ –Story Mass, x (10^3) Kg*	49.85– 59.85	52.1 – 62.1	57.5 – 67.5	64.1 – 74.1	71.9 – 81.9

*Story Mass- an increment of 2000 Kgs have been taken in those intervals for each story, i.e a total of 6 cases for each story.

Table iv: Cases considered for investigating effect of number of bays.

PARAMETER	Value Number								
	1	2	3	4	5	6	7	8	9
p – No. of bays	2	3	4	5	6	7	8	9	10

While carrying out the investigation of a parameter the rest are kept constant to see its effect on period clearly. A combination of all the cases for each parameter have been investigated turn by turn resulting in 200 models and can be found attached in the appendix.

Table v: Cross sectional dimensions of beam and columns considered for study.

NUMBER OF STORIES	BEAM DIMENSION, mm	$I_b(m^4)$	COLUMN DIMENSION, mm	$I_c(m^4)$
3	250x400	0.001333	350x350	0.001251
5	250x400	0.001333	400x400	0.002133
10	250x400	0.001333	500x500	0.005208
15	250x400	0.001333	600x600	0.010800
20	250x400	0.001333	700x700	0.020008

The above constant values are dependent on story levels. From the requirement of gravity load analysis as the number of stories increases so does the column dimensions with their associated masses. The remaining parameters are not story dependent.

Table vi: Constant values for the parameters that do not vary with story number.

PARAMETER	Constant Values
l – Beam Span (m)	5
h –Column Height (m)	3
p – Number of Bays	4

In addition the slab thickness is considered to be 0.15 m for all the cases and the unit weight of C-25 concrete is taken as 25 KN/m^3.

2.4 Modal Analysis Technique

In the majority of analyses carried out by engineers the forces are treated as static and even in situations where the forces are not actually constant with time they are considered to change sufficiently slowly that dynamic effects are not significant. If the force acting on the structure changes at such rate that the inertial and damping forces have a significant effect on the equation of equilibrium, then a dynamic analysis is required [5]

In some cases like the proposed 2005 edition of the National Building Code of Canada, it specifies dynamic analysis as the preferred method for computing seismic design forces and deflections, while maintaining the equivalent static force method for areas of low seismicity and for buildings with certain height limitations.

The equivalent static force procedure is permitted for buildings in low seismic regions, regular buildings below a certain height limit, and short buildings with certain irregularities. It may be preferred by designers because of its simplicity when dynamic analysis is not mandatory. In the 2005 NBCC, dynamic analysis is mandatory for the following classifications of buildings: (i) regular structures that are 60 m or taller or have fundamental period greater than or equal to 2.0 s and are located in areas of high seismicity with $I_E F_a S_a$ (0.2) $\geq$0.35, where I_E is the moment of inertia, F_a is an acceleration-based site coefficient, and S_a (0.2) is the spectral response acceleration for a period of 0.2 s; (ii) irregular buildings that are 20 m or taller or have a fundamental period of 0.5 s or longer and are located in areas of high seismicity with $I_E F_a S_a$ (0.2)$\geq$0.35; and (iii) all buildings that have rigid diaphragms and are torsionally sensitive.

When free vibration is under consideration, the structure is not subjected to any external excitation (force or support motion) and its motion is governed only by the initial conditions. There are occasionally circumstances for which it is necessary to determine the motion of the structure under conditions of free vibration. However, the analysis of the structure in free motion provides the most important dynamic properties of the structure which are the natural frequencies and the corresponding modal shapes.

The natural frequency of free vibration associated with a single degree of freedom system vibrating in simple harmonic motion has its equivalent in multi-degree of freedom systems. At each natural frequency of free vibration the structure vibrates in simple harmonic motion where the displaced shape, or mode shape, of the structure is constant but the amplitude of the displacement is varying in a sinusoidal manner with time. A system with N degrees of freedom has N natural frequencies of free vibration and N mode shapes of free vibration {**Ø**}, this set of N mode shapes forms a basis set of displacement vectors in that any displacement shape of the structure can be made up of a combination of these linearly independent mode shapes. Luckily, most engineers are generally only concerned with a small number of these modes, i.e. those associated with the few lowest natural frequencies of free vibration [5].

The Complete dynamic equilibrium of a multi degree of freedom structure is given by

$$[m]\{\ddot{U}\}+[c]\{\mathring{U}\}+[k]\{U\} = \{p(t)\} \quad (3)$$

Where, [m] = mass matrix
[c] = damping matrix
[k] = stiffness matrix
{p (t)} = load vector
{Ü} = acceleration vector
{Ů} = velocity vector
{U} = displacement vector

For free vibration of an undamped MDOF frame structure, Eq. 3 simplifies to

$$[m]\{\ddot{U}\}+[k]\{U\} = \{0\} \quad (4)$$

For a nontrivial solution of the above equations it can be shown (Clough and Penzien 1993) that the following determinant equation must satisfy

$$\|[k] - \boldsymbol{\omega}^2[m]\| = 0 \quad (5)$$

Where, $\boldsymbol{\omega}^2$ represent the frequencies of the N modes of vibration which are possible in the system.

SAP 2000 solves the problem by extracting Eigen values which represent frequencies and Eigen vectors representing mode shapes.

The vector made up of the entire set of modal frequencies, arranged in sequence, is the frequency vector, { **ω**}. For the real, symmetric, positive definite mass and stiffness matrices which pertain to a stable frame structure, all the frequencies will be real and positive. The lowest among these, $\boldsymbol{\omega_1}$ will correspond to the first mode. The fundamental period, T of the frame structure can then be determined as

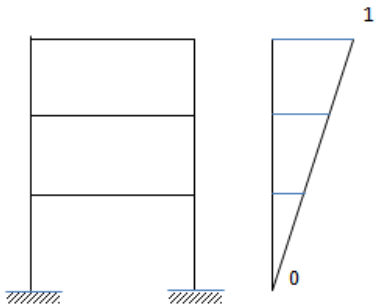
$$T_1 = \frac{2\pi}{\omega_1} \quad (6)$$

It should be noted that particularly for tall structures, the use of dynamic analysis methods will not only result in a more realistic characterization of the distribution of inertial forces in the structure, but may also result in reduced forces, particularly with regard to overturning demands. Therefore, use of a dynamic analysis method is recommended for such

structures, regardless of the Seismic Design Category [16].

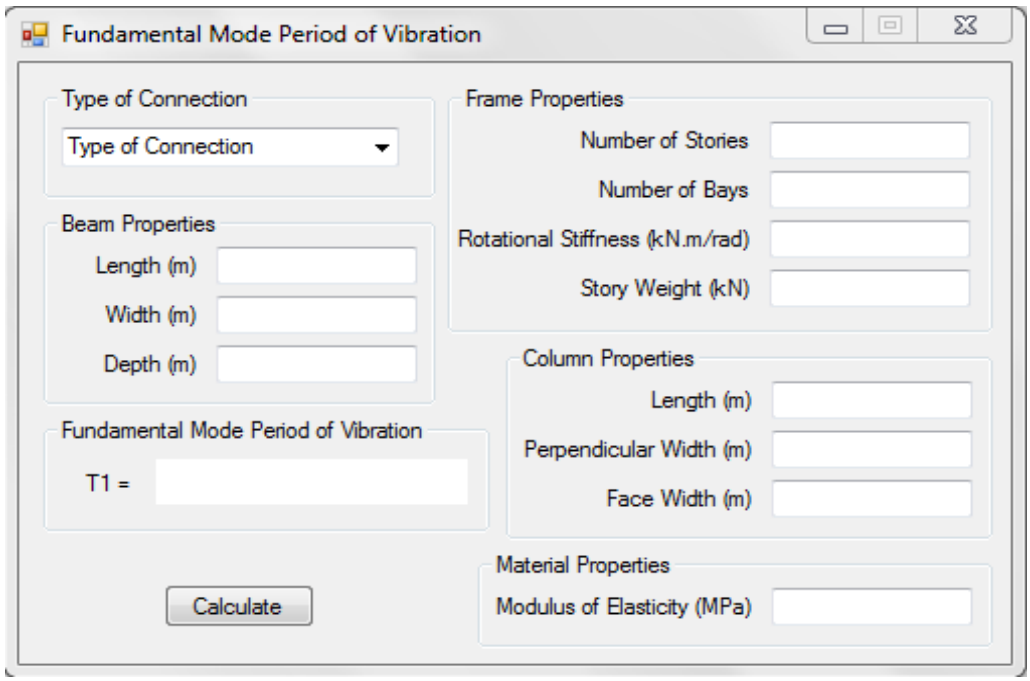
After analyzing the models using SAP 2000 v14 their periods have been recorded and compared with periods computed using Rayleigh's formula described in Chapter 2.

Figure 2: Assumed mode shape of vibration for Rayleigh's formula



A simple program is written in Visual Basic 2008 to calculate period using Rayleigh's formula and can be found attached in the Appendix.

Figure 3: Analysis tool box to calculate period using Rayleigh's formula programmed using Visual Basic 2008.



Finally new relationships were developed between period and the investigated parameters. The new relations were developed, by taking all seven parameters (beam span, column height, story mass, number of stories, and number of bays) in different combinations. The relations were developed, by taking 200 samples, and multiple linear regressions was then made using SPSS v20 for IBM software.

The multiple regression equations take the form $y=b_1x_1+b_2x_2+-----+c$. The b's are the regression coefficients, representing the amount the dependent variable changes when the independent changes one unit. The c is the constant, where the regression line intercepts the y axis, representing the amount the dependent y will take when all the independent variables are

zero.

The regression coefficients were then calculated using the statistical tool, SPSS v20 for IBM software, and tested for selected samples, which are used as a control to test the relations.

Generally the steps undertaken in the present study to achieve the above-mentioned objectives are as follows:

a. Carry out extensive literature review, to establish the objectives of the research work.
b. Select an exhaustive set of moment resisting building frame models with different heights (3 to 20 stories), beam & column dimensions, beam spans and column heights and different bay masses.
c. Perform modal analysis for each of the building models using SAP 2000 v14.
d. Analyzing and recording the results of modal analysis
e. Developing new empirical expression to calculate period

This chapter presented details of the structural models used for the analysis of fundamental period of vibration. It also described the selected building frame geometries used in the present study. The selected building frames are representing the realistic regular and symmetric two dimensional buildings of 3-20 stories. Modal analysis technique used in the present study is also explained in this chapter.

3. Results and Discussions

3.1 Introduction

This chapter presents the analysis results and appropriate discussions. According to the objectives of the present study, the results presented here are focused on fundamental time period of selected regular RC MRF buildings. The details of the selected building frames and the outline of the analysis procedure followed in this study are presented in Chapter 2.

All the selected building frame models with different geometries were analyzed for linear dynamic behavior using commercial software SAP2000 (v14).

3.2 Fundamental Time Period for Regular RC MRF Buildings

The fundamental time periods of 200 selected regular RC MRF buildings were calculated using modal analysis technique and Rayleigh's formula. The results are tabulated and shown in graphs for each parameter.

The parameters selected for investigating their effect on fundamental period all translate into mass and stiffness characteristics of the building frames, thus it's important to see the effect of each parameter on **story mass** and **story stiffness**.

Story mass is calculated by taking the cross sectional dimensions of the members and multiplying it by unit weight of C-25 grade of concrete and number of bays.

By taking depth of slab 0.15m and center to center spacing of frames 5m

$\mathbf{m_s}$= {(0.15×5×**l**×25) + (**b**×**d**×**l**×25) + (**b**×**d**×**h**×25)} ×100×**p**(7)

b×**d**- cross sectional area of beam and column

For calculation of lateral story stiffness of MRF an approximate estimate proposed by Schultz (1992) is used. The relationship is given by,

$$K_s = \left(\frac{24}{h^2}\right)\left(\frac{1}{\frac{2}{\sum K_c}+\frac{1}{\sum K_{ba}}+\frac{1}{\sum K_{bb}}}\right)(8)$$

Where $\sum K_c$ – is the sum of relative flexural stiffness of columns in the story (i.e $=\frac{EI_c}{h}$)

in kN-m

$\sum K_{ba}$ – is the sum of relative flexural stiffness of beams above the story (i.e =$\frac{EI_b}{l}$) in kN-m

$\sum K_{bb}$ – is the sum of relative flexural stiffness of beams below the story (i.e =$\frac{EI_b}{l}$) in kN-m

h - is the column heightin m

E – is the modulus of elasticity (according to EBCS-2 for C-25, E = 29 Gpa)

I_b&I_c– are the moment of inertias for beam and column in m^4 respectively

And K_s– is the lateral story stiffness in kN/m.

For the first story of a frame with fixed base $\sum K_{bb}$ is taken equal to infinity, thus eliminating the corresponding term in the denominator of (8).

The story stiffness calculations were estimated accordingly for bottom, intermediate and top stories of each frame. Since bottom story stiffness is larger than the intermediate and top stories (which are constant for uniform frames) effect of parameters was considered for this study on bottom story stiffness.

3.2.1Column Height

The values selected for the investigation of these parameters are presented in Chapter 3. There are altogether 125 sample frame models analyzed for these parameters.

Table vii: Period Values for a 3 Story with varying beam span & story stiffness.

l	h	K_s(bottom) $\times(10^3)$ kN/m	$m_s\times(10^3)$ Kg	T_1 (MODAL)	T_1 (EBCS-8)	T_1 (RAYLEIGH)	% Δ(T_1-MODAL & T_1-EBCS-8)
3	2.6	47.56	31.12	0.65	0.35	0.41	46.34
3	3.0	33.73	32.10	0.81	0.39	0.49	51.89
3	3.5	23.16	33.33	0.97	0.44	0.59	55.10
3	4.0	16.65	34.55	1.26	0.48	0.71	61.71
3	5.0	9.49	37.00	1.80	0.57	0.95	68.18
4	2.6	52.77	39.87	0.73	0.35	0.43	52.11
4	3.0	37.19	40.85	0.90	0.39	0.52	56.90
4	3.5	25.37	42.08	1.14	0.44	0.63	61.65
4	4.0	18.13	43.30	1.40	0.48	0.75	65.43
4	5.0	10.24	45.75	1.98	0.57	1.00	71.07
5	2.6	58.20	48.87	0.80	0.35	0.45	56.29
5	3.0	40.76	49.85	0.99	0.39	0.54	60.57
5	3.5	27.62	51.08	1.24	0.44	0.65	64.82
5	4.0	19.62	52.30	1.52	0.48	0.78	68.21
5	5.0	10.97	54.75	2.14	0.57	1.05	73.28
6	2.6	69.09	59.47	0.87	0.35	0.46	59.53
6	3.0	47.79	60.45	1.07	0.39	0.55	63.44
6	3.5	31.96	61.68	1.34	0.44	0.66	67.32
6	4.0	22.45	62.90	1.64	0.48	0.78	70.43
6	5.0	12.33	65.35	2.29	0.57	1.06	75.08

7	2.6	73.98	69.37	0.93	0.35	0.46	62.18
7	3.0	50.89	70.35	1.14	0.39	0.55	65.80
7	3.5	33.83	71.58	1.43	0.44	0.67	69.40
7	4.0	23.65	72.80	1.74	0.48	0.80	72.27
7	5.0	12.89	75.25	2.44	0.57	1.08	76.59

Figure 4: Period Values for a 3 Story with 3m beam span& varying story stiffness.

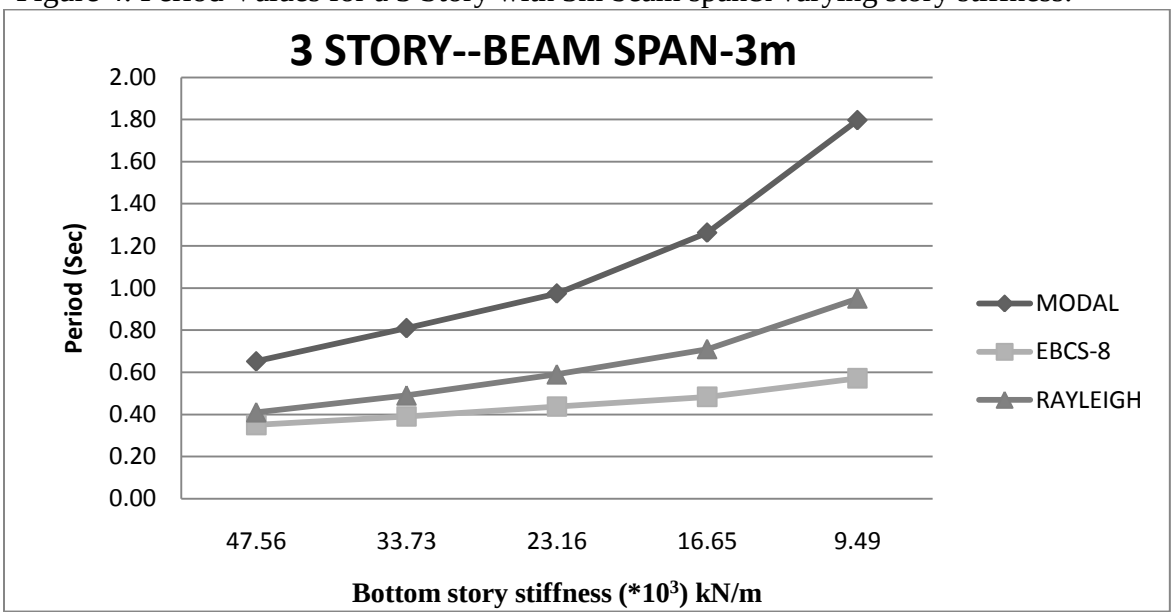


Table vii presented period values for a 3 story MRF obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the variations the results for a beam span of 3m have also been plotted in graphs shown in Figure 11.

It can be seen from the results that fundamental period is significantly influenced by increase in column height which results in decrease of story stiffness and increase of story mass causing period to increase. It can also be observed that increase in beam span increases both the story stiffness and the story mass which in turn increases period.

The graphical illustration of the results for the remaining beam spans can be found attached in the appendix. The % difference between periods found from modal analysis and EBCS-8 is also given in the table.

Table viii: Period Values for a 5 Story with varying beam span & column heights.

l	**h**	**K_s(bottom) $\times(10^3)$ kN/m**	**$m_s\times(10^3)$ Kg**	**T_1 (MODAL)**	**T_1 (EBCS-8)**	**T_1 (RAYLEIGH)**	**% Δ (T_1-MODAL & T_1-EBCS-8)**
3	2.6	56.54	33.07	0.69	0.51	0.63	25.35
3	3.0	40.79	34.35	0.86	0.57	0.75	33.29
3	3.5	28.56	35.95	1.09	0.64	0.91	41.12
3	4.0	20.88	37.55	1.35	0.71	1.08	47.31
3	5.0	12.26	40.75	1.93	0.84	1.45	56.48
4	2.6	64.07	41.82	0.77	0.51	0.66	33.03
4	3.0	45.98	43.10	0.95	0.57	0.79	39.88

4	3.5	31.99	44.70	1.20	0.64	0.95	46.67
4	4.0	23.27	46.30	1.48	0.71	1.13	52.05
4	5.0	13.53	49.50	2.10	0.84	1.50	60.09
5	2.6	72.25	50.82	0.84	0.51	0.69	38.67
5	3.0	51.56	52.10	1.04	0.57	0.81	44.77
5	3.5	35.65	53.70	1.31	0.64	0.98	50.84
5	4.0	25.78	55.30	1.60	0.71	1.16	55.66
5	5.0	14.85	58.50	2.26	0.84	1.54	62.89
6	2.6	89.85	61.42	0.90	0.51	0.69	43.07
6	3.0	63.34	62.70	1.11	0.57	0.82	48.61
6	3.5	43.22	64.30	1.40	0.64	0.99	54.12
6	4.0	30.89	65.90	1.71	0.71	1.17	58.52
6	5.0	17.44	69.10	2.40	0.84	1.55	65.13
7	2.6	98.29	71.32	0.96	0.51	0.71	46.67
7	3.0	68.89	72.60	1.19	0.57	0.83	51.78
7	3.5	46.71	74.20	1.49	0.64	1.01	56.87
7	4.0	33.21	75.80	1.82	0.71	1.21	60.95
7	5.0	18.59	79.00	2.55	0.84	1.59	67.08

Table viii presented period values for a 5 story MRF obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the variations the results for a beam span of 4m have also been plotted in graphs shown in Figure 12 below.

It can be seen from the results that fundamental period is significantly influenced by increase in column height which results in decrease of story stiffness and increase of story mass causing period to increase. It can also be observed that increase in beam span increases both the story stiffness and the story mass which in turn increases period. The graphical illustration of the results for the remaining beam spans can be found attached in the appendix. The % difference between periods found from modal analysis and EBCS-8 is also given in the table.

Figure 5: Period Values for a **5 Story** with 4m beam span & varying story stiffness

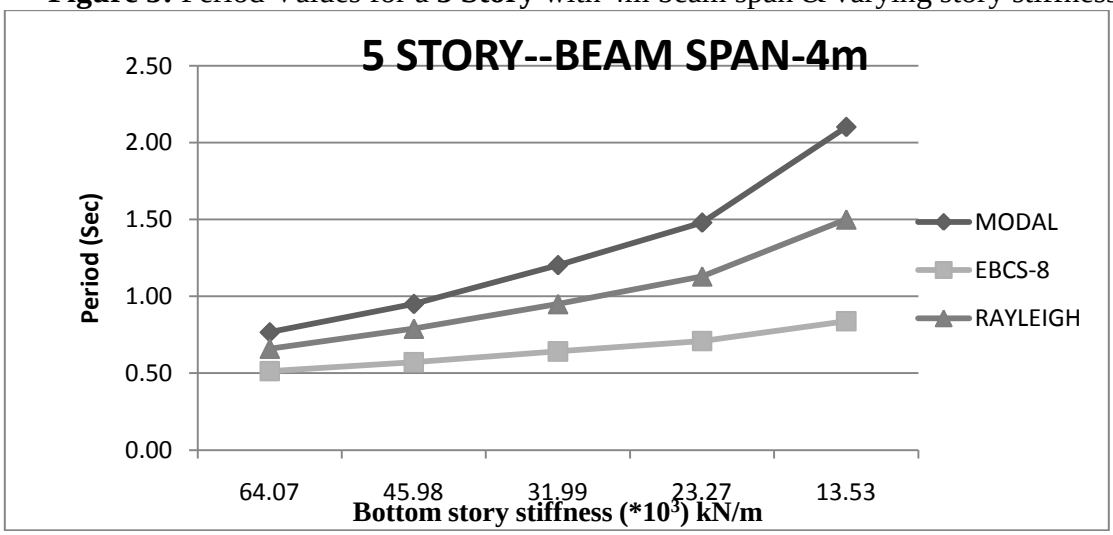


Table ix below presented period values for a 10 story MRF obtained from modal

analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the variations the results for a beam span of 5m have also been plotted in graphs shown in Figure 13 below.

Again here it can be seen from the results that fundamental period is significantly influenced by increase in column height which results in decrease of story stiffness and increase of story mass causing period to increase. It can also be observed that increase in beam span increases both the story stiffness and the story mass which in turn increases period.

Table ix: Period Values for a 10 Story with varying beam span& column heights.

l	**h**	**K_s(bottom) $\times(10^3)$ kN/m**	**$m_s\times(10^3)$ Kg**	**T_1 (MODAL)**	**T_1 (EBCS-8)**	**T_1 (RAYLEIGH)**	**% Δ (T_1-MODAL & T_1-EBCS-8)**
3	2.6	67.16	37.75	0.70	0.86	0.72	-23.67
3	3.0	49.45	39.75	0.88	0.96	0.81	-9.80
3	3.5	35.46	42.25	1.12	1.08	1.02	3.86
3	4.0	26.52	44.75	1.40	1.19	1.23	14.62
3	5.0	16.21	49.75	2.03	1.41	1.53	30.43
4	2.6	78.05	46.50	0.77	0.86	0.75	-12.03
4	3.0	57.29	48.50	0.96	0.96	0.84	-0.01
4	3.5	40.92	51.00	1.23	1.08	1.06	11.90
4	4.0	30.49	53.50	1.52	1.19	1.29	21.33
4	5.0	18.52	58.50	2.18	1.41	1.57	35.31
5	2.6	90.54	55.50	0.84	0.86	0.82	-3.19
5	3.0	66.22	57.50	1.09	0.96	0.97	12.09
5	3.5	47.10	60.00	1.32	1.08	1.16	18.17
5	4.0	34.95	62.50	1.63	1.19	1.35	26.63
5	5.0	21.07	67.50	2.32	1.41	1.66	39.24
6	2.6	119.98	66.10	0.90	0.86	0.91	4.06
6	3.0	87.01	68.10	1.11	0.96	1.06	13.68
6	3.5	61.27	70.60	1.41	1.08	1.28	23.27
6	4.0	45.05	73.10	1.73	1.19	1.44	30.93
6	5.0	26.71	78.10	2.45	1.41	1.75	42.41
7	2.6	135.53	76.00	0.96	0.86	1.01	9.86
7	3.0	97.84	78.00	1.18	0.96	1.21	18.69
7	3.5	68.55	80.50	1.49	1.08	1.46	27.53
7	4.0	50.16	83.00	1.82	1.19	1.62	34.60
7	5.0	29.49	88.00	2.54	1.41	1.91	44.53

The graphical illustration of the results for the remaining beam spans can be found attached in the appendix. The % difference between periods found from modal analysis and EBCS-8 is also given in the table.

Figure 6: Period Values for a 10 Story with 5m beam span&varying story stiffness.

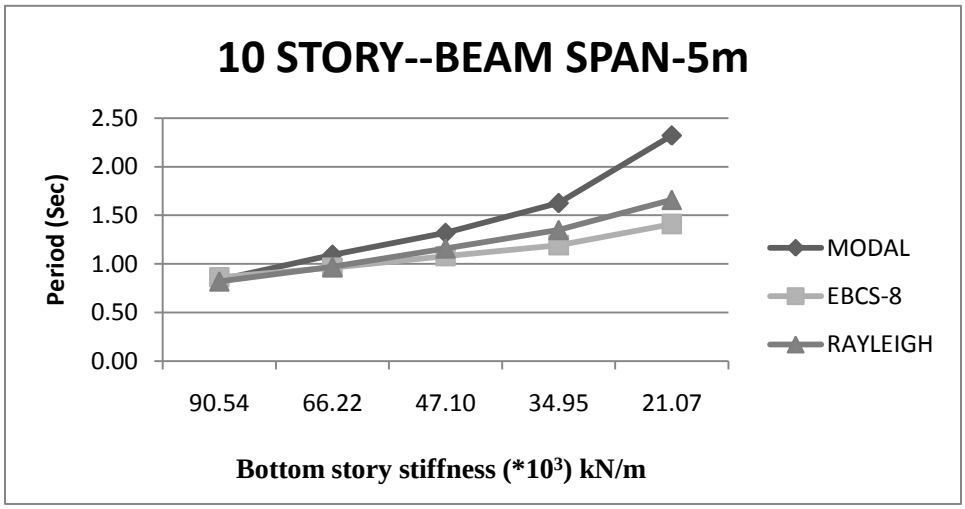


Table x: Period Values for a 15 Story with varying beam span& column heights.

l	h	K_s(bottom) $\times(10^3)$ kN/m	$m_s\times(10^3)$ Kg	T_1 (MODAL)	T_1 (EBCS-8)	T_1 (RAYLEIGH)	% Δ (T_1-MODAL & T_1-EBCS-8)
3	2.6	72.02	43.47	0.77	1.17	0.84	-51.63
3	3.0	53.54	46.35	0.97	1.30	0.95	-33.88
3	3.5	38.84	49.95	1.26	1.46	1.21	-16.45
3	4.0	29.36	53.55	1.57	1.62	1.53	-2.78
3	5.0	18.33	60.75	2.31	1.91	1.78	17.16
4	2.6	84.68	52.22	0.84	1.17	0.91	-38.93
4	3.0	62.84	55.10	1.06	1.30	1.05	-23.37
4	3.5	45.48	58.70	1.35	1.46	1.30	-7.99
4	4.0	34.31	62.30	1.69	1.62	1.64	4.15
4	5.0	21.34	69.50	2.45	1.91	1.85	22.02
5	2.6	99.59	61.22	0.91	1.17	1.07	-28.92
5	3.0	73.75	64.10	1.13	1.30	1.18	-15.00
5	3.5	53.24	67.70	1.45	1.46	1.49	-1.16
5	4.0	40.07	71.30	1.79	1.62	1.77	9.81
5	5.0	24.80	78.50	2.59	1.91	1.96	26.07
6	2.6	136.42	71.82	0.97	1.17	1.16	-20.43
6	3.0	100.49	74.70	1.21	1.30	1.28	-7.91
6	3.5	72.10	78.30	1.53	1.46	1.55	4.61
6	4.0	53.93	81.90	1.89	1.62	1.92	14.57
6	5.0	33.00	89.10	2.71	1.91	2.06	29.43
7	2.6	156.88	81.72	1.03	1.17	1.19	-13.59
7	3.0	115.23	84.60	1.28	1.30	1.34	-2.07
7	3.5	82.39	88.20	1.62	1.46	1.65	9.46
7	4.0	61.43	91.80	1.97	1.62	1.98	17.99
7	5.0	37.36	99.00	2.83	1.91	2.15	32.48

Table x above presented period values for a 15 story MRF obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the variations the results for a beam span of 6m have also been plotted in graphs shown in Figure 14 below.

It can be seen from the results that fundamental period is significantly influenced by increase in column height which results in decrease of story stiffness and increase of story mass causing period to increase. It can also be observed that increase in beam span increases both the story stiffness and the story mass which in turn increases period. The graphical illustration of the results for the remaining beam spans can be found attached in the appendix.

Figure 7: Period Values for a 15 Story with 6m beam span& varying story stiffness.

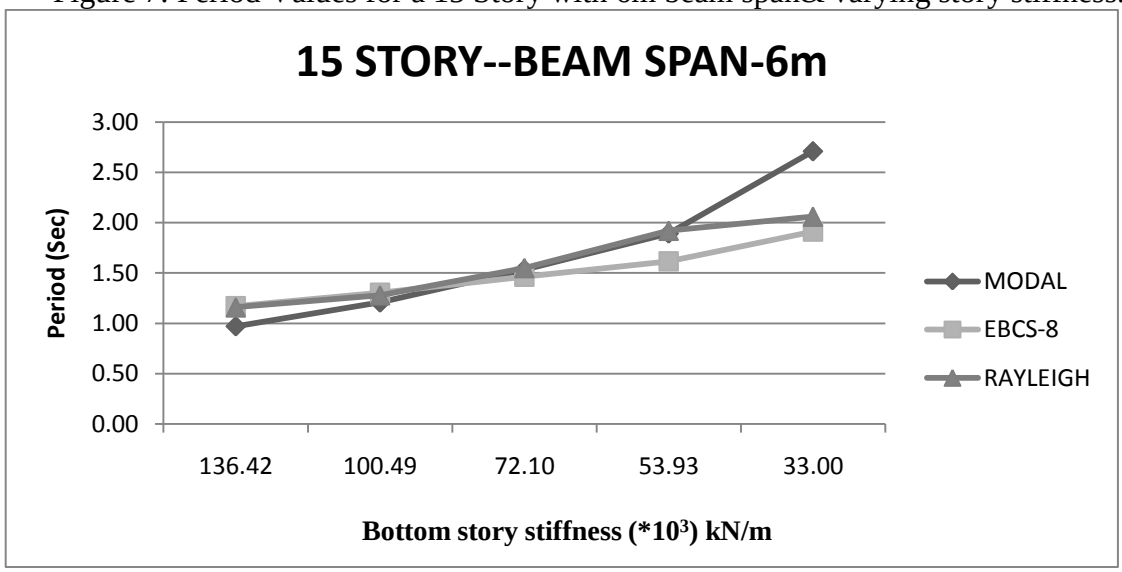


Table xi below presented period values for a 20 story MRF obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the variations the results for a beam span of 7m have also been plotted in graphs shown in Figure 15 below.

Again here it can be seen from the results that fundamental period is significantly influenced by increase in column height which results in decrease of story stiffness and increase of story mass causing period to increase. It can also be observed that increase in beam span increases both the story stiffness and the story mass which in turn increases period.

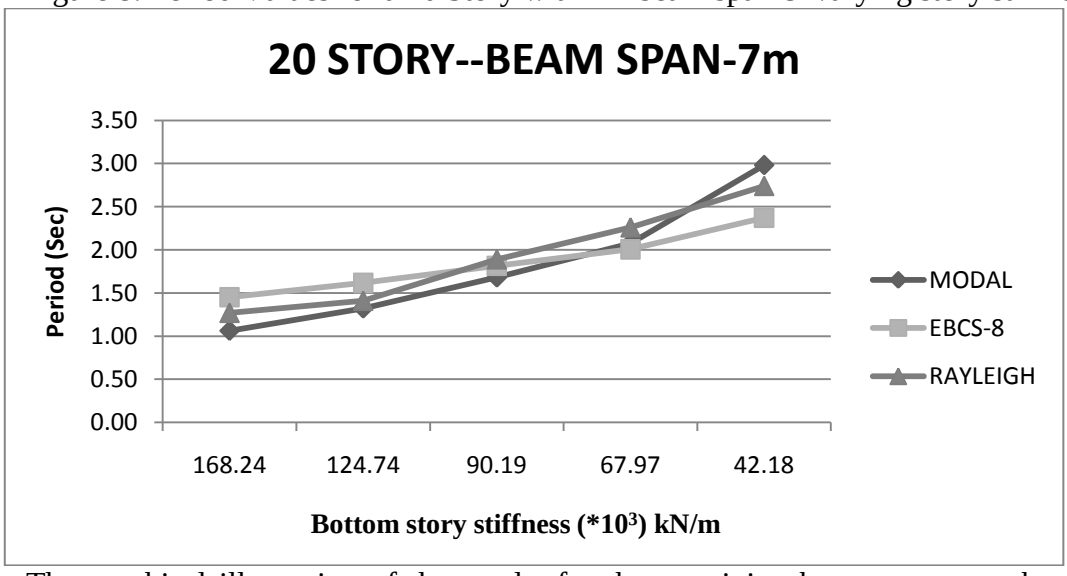
The graphical illustration of the results for the remaining beam spans can be found attached in the appendix.

Table xi: Period Values for a 20 Story with varying beam span& column heights.

l	**h**	**K_s(bottom) $\times(10^3)$ kN/m**	**$m_s\times(10^3)$ Kg**	**T_1 (MODAL)**	**T_1 (EBCS-8)**	**T_1 (RAYLEIGH)**	**% Δ (T_1-MODAL & T_1-EBCS-8)**
3	2.6	74.32	50.23	0.82	1.45	0.97	-77.72
3	3.0	55.50	54.15	1.04	1.62	1.19	-56.20
3	3.5	40.49	59.05	1.34	1.82	1.42	-35.14
3	4.0	30.78	63.95	1.69	2.01	1.77	-18.69
3	5.0	19.42	73.75	2.50	2.37	2.28	5.14
4	2.6	87.89	58.98	0.88	1.45	1.09	-64.49
4	3.0	65.56	62.90	1.11	1.62	1.25	-45.44

4	3.5	47.76	67.80	1.43	1.82	1.65	-26.63
4	4.0	36.27	72.70	1.79	2.01	1.96	-11.84
4	5.0	22.83	82.50	2.63	2.37	2.41	9.82
5	2.6	104.05	67.98	0.94	1.45	1.13	-53.73
5	3.0	77.53	71.90	1.18	1.62	1.29	-37.47
5	3.5	56.40	76.80	1.52	1.82	1.73	-19.54
5	4.0	42.75	81.70	1.89	2.01	2.09	-6.05
5	5.0	26.83	91.50	2.75	2.37	2.53	13.85
6	2.6	144.93	78.58	1.01	1.45	1.19	-44.37
6	3.0	107.64	82.50	1.26	1.62	1.34	-28.83
6	3.5	78.00	87.40	1.60	1.82	1.80	-13.34
6	4.0	58.91	92.30	1.99	2.01	2.12	-1.02
6	5.0	36.71	102.10	2.86	2.37	2.66	17.12
7	2.6	168.24	88.48	1.06	1.45	1.27	-36.72
7	3.0	124.74	92.40	1.32	1.62	1.41	-22.41
7	3.5	90.19	97.30	1.68	1.82	1.89	-8.08
7	4.0	67.97	102.20	2.08	2.01	2.26	3.37
7	5.0	42.18	112.00	2.98	2.37	2.74	20.43

Figure 8: Period Values for a 20 Story with 7m beam span & varying story stiffness.



The graphical illustration of the results for the remaining beam spans can be found attached in the appendix.

It is seen from the analysis results that an increase in column height results in decrease of story stiffness and increase in story mass a more detailed assessment of this fact is presented in the following table.

Table xii : Effect of column height on story stiffness and story mass

3 story	**Δh (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm_s, $\times 10^3$ (Kg)**	**% m_s**
Top & Intermediate story	0.5	-11.78	-31.8	1.23	3.73
Bottom story	0.5	-17.03	-33.5	1.23	3.73
5 story	**Δh (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm_s, $\times 10^3$ (Kg)**	**% m_s**
Top & Intermediate story	0.5	-13.93	-30.4	1.60	4.56
Bottom story	0.5	-22.12	-32.2	1.60	4.56
10 story	**Δh (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm_s, $\times 10^3$ (Kg)**	**% m_s**
Top & Intermediate story	0.5	-16.29	-28.55	2.50	6.17
Bottom story	0.5	-29.19	-29.92	2.50	6.17
15 story	**Δh (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm_s, $\times 10^3$ (Kg)**	**% m_s**
Top & Intermediate story	0.5	-17.28	-27.62	3.60	7.64
Bottom story	0.5	-32.71	-28.50	3.60	7.64
20 story	**Δh (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm_s, $\times 10^3$ (Kg)**	**% m_s**
Top & Intermediate story	0.5	-17.72	-27.15	4.90	8.93
Bottom story	0.5	-34.40	-27.69	4.90	8.93

Table xii provides % changes in story stiffness (top, intermediate and bottom) and story mass when the column height increases from3 to 3.5m for all stories considered in this study.

In general when column height increases from 3to3.5m, bottom story stiffness decreases by 30.62% top and intermediate stories also decrease by 29.1% on average while story mass increases by 6.2% for all stories on average.

It is observed that for the same overall building height but with different column heights EBCS-8 empirical formula gives similar fundamental periods while SAP 2000's output and Rayleigh's formula yield different periods. A good case in point is the periods of a 3 story frame with 5m column height and a 5 story frame with 3m column height. In both cases the overall building height is 15m hence EBCS-8 gives a period of 0.5716 for both cases while SAP 2000's output and Rayleigh's formula give 0.8& 0.45 for the first case and 1.04& 0.81 for the second case respectively.

It can be further noted that the difference in period between Modal analysis and EBCS-8 is positive in the 3 – 10 storey range which indicates that the code underestimates period in this range. Starting from and above 10 stories the difference is negative which suggests that period is slightly overestimated when evaluated using the code formula.

The % differences in period between SAP 2000 and EBCS-8 out puts are given for all the cases.

3.2.2 Beam Span

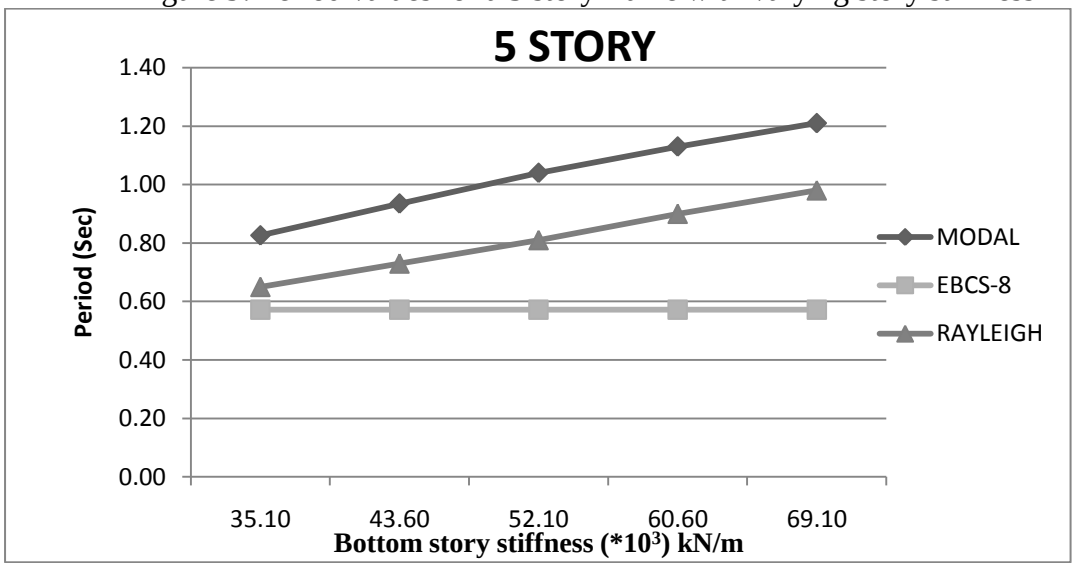
To clearly see the effect of beam span on story stiffness and story mass and let alone on period, separate analysis is carried out by keeping the column height constant for every story considered in this study and is presented in the table below.

Table 1: Effect of beam span on story stiffness, story mass and period.

l	h	s	K_s(bottom) $\times(10^3)$ kN/m	$m_s\times(10^3)$ Kg	T_1 (MODAL)	T_1 (EBCS-8)	T_1 (RAYLEIGH)	% Δ (T_1-MODAL & T_1-EBCS-8)
3	3.0	3	50.81	32.85	0.78	0.39	0.38	50.04
4	3.0	3	45.23	41.35	0.89	0.39	0.46	56.21
5	3.0	3	40.76	49.85	0.99	0.39	0.54	60.64
6	3.0	3	37.10	58.35	1.08	0.39	0.62	63.92
7	3.0	3	34.04	66.85	1.17	0.39	0.71	66.69
3	3.0	5	68.74	35.10	0.83	0.57	0.65	30.79
4	3.0	5	58.92	43.60	0.94	0.57	0.73	38.86
5	3.0	5	51.56	52.10	1.04	0.57	0.81	45.03
6	3.0	5	45.83	60.60	1.13	0.57	0.90	49.41
7	3.0	5	41.24	69.10	1.21	0.57	0.98	52.76
3	3.0	10	97.53	40.50	0.89	0.96	0.81	-8.02
4	3.0	10	78.88	49.00	0.99	0.96	0.89	2.89
5	3.0	10	66.22	57.50	1.09	0.96	0.97	11.80
6	3.0	10	57.06	66.00	1.20	0.96	1.06	19.88
7	3.0	10	50.12	74.50	1.31	0.96	1.14	26.61
3	3.0	15	114.80	47.10	0.93	1.30	1.02	-40.43
4	3.0	15	89.81	55.60	1.03	1.30	1.11	-26.13
5	3.0	15	73.75	64.10	1.13	1.30	1.18	-15.32
6	3.0	15	62.56	72.60	1.23	1.30	1.27	-5.96
7	3.0	15	54.32	81.10	1.33	1.30	1.34	1.91
3	3.0	20	124.24	54.90	0.98	1.62	1.13	-65.54
4	3.0	20	95.48	63.40	1.07	1.62	1.21	-50.52
5	3.0	20	77.53	71.90	1.18	1.62	1.29	-37.47
6	3.0	20	65.26	80.40	1.27	1.62	1.38	-27.13
7	3.0	20	56.35	88.90	1.38	1.62	1.46	-17.43

When the column height is fixed an increase in beam span alone results in decrease of story stiffness (when column height increases an increase in beam span increases story stiffness) and increase in story mass which resulted in an increase in fundamental period. Table xiii above presented period values for all stories obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the variations the results for a 5 story frame have also been plotted in graphs shown in Figure 16 below.

Figure 9: Period values for a 5 story frame with varying story stiffness



It is seen from the analysis results that an increase in beam span results in decrease of story stiffness and increase in story mass a more detailed assessment of this fact is presented in the following table.

Table xiv: Effect of beam span on story stiffness and story mass

3 story		**Top & Intermediate**		**Bottom**			
l (m)	**Δl (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$ (Kg)**	**% m**
3	—	—	-15.25	—	-10.97	—	25.88
4	1	-5.66	—	-5.57	—	8.50	—
5 story		**Top & Intermediate**		**Bottom**			
l (m)	**Δl (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$ (Kg)**	**% m**
3	—	—	-18.18	—	-14.29	—	24.22
4	1	-8.33	—	-9.82	—	8.50	—
10 story		**Top & Intermediate**		**Bottom**			
l (m)	**Δl (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$ (Kg)**	**% m**
3	—	—	-21.67	—	-19.12	—	20.99
4	1	-12.36	—	-18.65		8.50	
15 story		**Top & Intermediate**		**Bottom**			
l (m)	**Δl (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$ (Kg)**	**% m**
3	—	—	-23.28	—	-21.77	—	18.05

4	1	-14.56	—	-25.00	—	8.50	—
20 story		**Top & Intermediate**		**Bottom**			
l (m)	**Δl (m)**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$ (Kg)**	**% m**
3	—	—	-24.04	—	-23.15	—	15.48
4	1	-15.69	—	-28.76	—	8.50	—

Table xiv provides % changes in story stiffness (top, intermediate & bottom) and story mass when the beam span increases from3m to 4m for all stories considered in this study.

In general when beam span increases from 3m to 4m, bottom story stiffness decreases by 17.86%, top & intermediate stories also decrease by 20.48% on average while story mass increases by 20.92% for all stories on average. Hence both a decrease in story stiffness and an increase in story mass result in increase in period.

3.2.3 Story Mass

The values considered for the investigation of this parameter are given in table iii. There are altogether 30 sample frame models analyzed for this parameter.

Table xv: Period Values for a 3 Story with varying story masses.

l	**h**	**s**	**K_s(bottom) $\times (10^3)$ kN/m**	**$m_s \times (10^3)$ Kg**	**T_1 (MODAL)**	**T_1 (EBCS-8)**	**T_1 (RAYLEIGH)**	**% Δ (T_1-MODAL & T_1-EBCS-8)**
5	3.0	3	40.76	49.85	0.99	0.39	0.54	60.61
5	3.0	3	40.76	51.85	1.01	0.39	0.55	61.31
5	3.0	3	40.76	53.85	1.03	0.39	0.56	62.14
5	3.0	3	40.76	55.85	1.05	0.39	0.57	62.86
5	3.0	3	40.76	57.85	1.06	0.39	0.58	63.37
5	3.0	5	40.76	59.85	1.08	0.39	0.59	63.89
5	3.0	5	51.56	52.10	1.04	0.57	0.81	45.19
5	3.0	5	51.56	54.10	1.06	0.57	0.82	46.23
5	3.0	5	51.56	56.10	1.07	0.57	0.83	46.73
5	3.0	5	51.56	58.10	1.09	0.57	0.84	47.71
5	3.0	10	51.56	60.10	1.11	0.57	0.85	48.65
5	3.0	10	51.56	62.10	1.13	0.57	0.86	49.56
5	3.0	10	66.22	57.50	1.09	0.96	0.97	11.93
5	3.0	10	66.22	59.50	1.11	0.96	0.98	13.51
5	3.0	10	66.22	61.50	1.13	0.96	0.99	15.04
5	3.0	15	66.22	63.50	1.15	0.96	1.00	16.52
5	3.0	15	66.22	65.50	1.16	0.96	1.01	17.24
5	3.0	15	66.22	67.50	1.18	0.96	1.02	18.64
5	3.0	15	73.75	64.10	1.13	1.30	1.18	-15.04
5	3.0	15	73.75	66.10	1.15	1.30	1.19	-13.04
5	3.0	20	73.75	68.10	1.17	1.30	1.20	-11.11
5	3.0	20	73.75	70.10	1.19	1.30	1.21	-9.24
5	3.0	20	73.75	72.10	1.20	1.30	1.22	-8.33

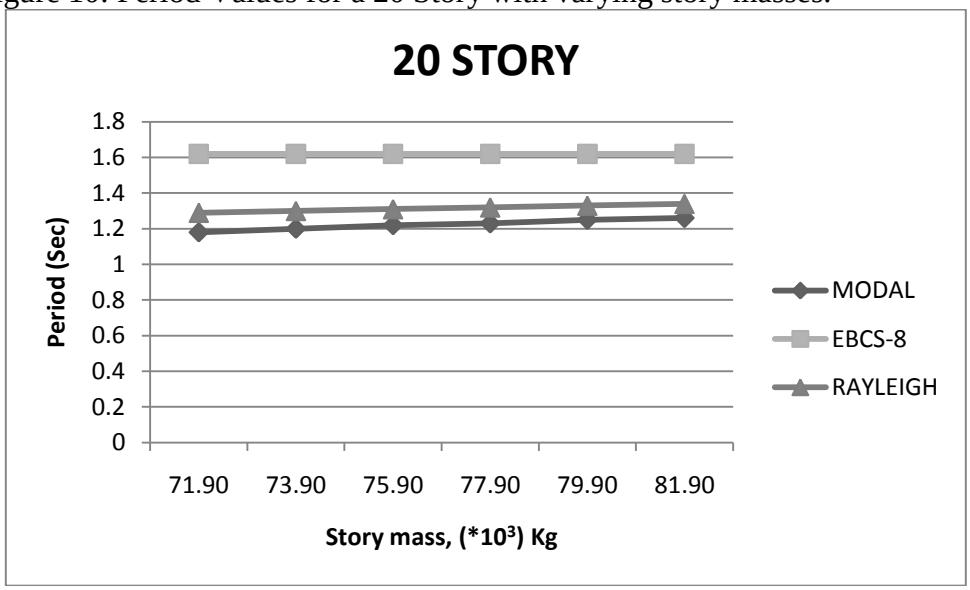
5	3.0	20	73.75	74.10	1.22	1.30	1.23	-6.56
5	3.0	20	77.53	71.90	1.23	1.62	1.29	-37.29

Table xv above presented period values for all stories obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the variations the results for a 20 frame has also been plotted in graphs shown in Figure 17 below.

It can be seen from the results that fundamental period increases with an increase in story mass. The period values obtained from EBCS-8 and Rayleigh's formula show a small difference.

The alterations in period between SAP 2000 and EBCS-8 are given in Table xix for all the cases.

Figure 10: Period Values for a 20 Story with varying story masses.



In general when story mass increases by 2000 Kg due to additional mass from partition walls and floor finishes story mass increases by 3.45% for all stories on average which resulted in increase of period by 1.85% on average. This is presented in detail in table xvi below.

Table xvi: Effect of story mass on period

(3 story)$m_s \times 10^3$ Kg	**Δm_s ($\times 10^3$),Kg**	**$\%m_s$**	**T_1 (Sec)**	**ΔT_1 (Sec)**	**$\% T_1$**
49.85	__	4.01	0.99	__	2.02
51.85	2	__	1.01	0.02	__
(5 story)$m_s \times 10^3$ Kg	**Δm_s ($\times 10^3$),Kg**	**$\%m_s$**	**T_1 (Sec)**	**ΔT_1 (Sec)**	**$\% T_1$**
52.10	__	3.84	1.04	__	1.92
54.10	2	__	1.06	0.02	__
(10 story)$m_s \times 10^3$ Kg	**Δm_s ($\times 10^3$),Kg**	**$\%m_s$**	**T_1 (Sec)**	**ΔT_1 (Sec)**	**$\% T_1$**
57.50	__	3.48	1.09	__	1.83
59.50	2	__	1.11	0.02	__
(15 story)$m_s \times 10^3$	**Δm_s**	**$\%m_s$**	**T_1**	**ΔT_1 (Sec)**	**$\% T_1$**

Kg	($\times 10^3$),Kg		(Sec)		
64.10	__	3.12	1.13	__	1.77
66.10	2	__	1.15	0.02	__
(20 story)$m_s \times 10^3$ Kg	Δm_s ($\times 10^3$),Kg	$\%m_s$	T_1 (Sec)	ΔT_1 (Sec)	$\% T_1$
71.90	__	2.78	1.18	__	1.69
73.90	2	__	1.20	0.02	__

3.2.4 Number of Bays

The values considered for the investigation of this parameter is given in table iv. There are altogether 45 sample frame models analyzed for this parameter.

Table xvii: Period Values for a 3 Story with varying number of bays.

l	h	P	K_s(bottom) $\times(10^3)$ kN/m	$m_s \times (10^3)$ Kg	T_1 (MODAL)	T_1 (EBCS-8)	T_1 (RAYLEIGH)	% Δ (T_1-MODAL & T_1-EBCS-8)
5	3.0	2	22.26	24.93	0.91	0.39	0.52	57.17
5	3.0	3	31.57	37.39	0.96	0.39	0.53	59.41
5	3.0	4	40.76	49.85	0.99	0.39	0.54	60.64
5	3.0	5	49.90	62.31	1.00	0.39	0.54	61.03
5	3.0	6	59.01	74.78	1.02	0.39	0.54	61.79
5	3.0	7	68.11	87.24	1.03	0.39	0.54	62.16
5	3.0	8	77.19	99.70	1.03	0.39	0.55	62.16
5	3.0	9	86.26	112.16	1.04	0.39	0.55	62.53
5	3.0	10	95.33	124.63	1.05	0.39	0.55	62.88

Figure 11: Period Values for a 3 Story with varying number of bays.

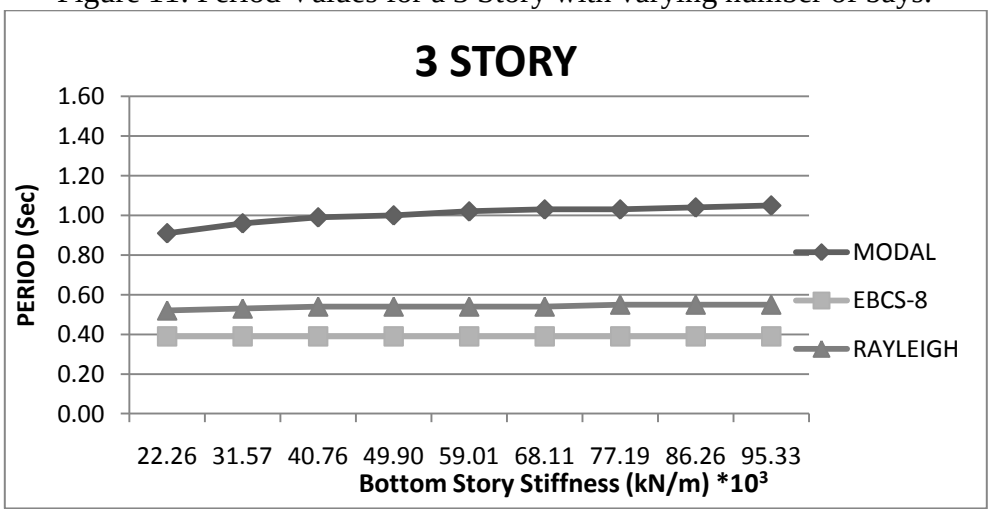


Table xvii above presented period values for a 3 story MRF obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the deviations the results for all the cases considered have also been plotted in graphs shown in Figure 18. It can also be grasped from the results that an increase in number of bays increases both story stiffness and story mass which caused a slight increase on fundamental period. The period values obtained from EBCS-8 and Rayleigh's formula display a small difference. The differences in period between SAP 2000 and EBCS-8 are given in Table xvii for all the cases.

Table xviii: Period Values for a 5 Story with varying number of bays.

l	h	p	K_s(bottom) $\times(10^3)$ kN/m	$m_s\times(10^3)$ Kg	T_1 (MODAL)	T_1 (EBCS-8)	T_1 (RAYLEIGH)	% Δ (T_1-MODAL & T_1-EBCS-8)
5	3.0	2	27.50	26.05	0.96	0.57	0.78	40.45
5	3.0	3	39.59	39.08	1.00	0.57	0.80	42.84
5	3.0	4	51.56	52.10	1.04	0.57	0.81	45.03
5	3.0	5	63.45	65.13	1.05	0.57	0.81	45.56
5	3.0	6	75.32	78.15	1.07	0.57	0.81	46.57
5	3.0	7	87.16	91.18	1.08	0.57	0.81	47.07
5	3.0	8	98.99	104.20	1.08	0.57	0.82	47.07
5	3.0	9	110.81	117.23	1.09	0.57	0.83	47.56
5	3.0	10	122.62	130.25	1.10	0.57	0.84	48.03

Figure 12: Period Values for a 5 Story with varying number of bays.

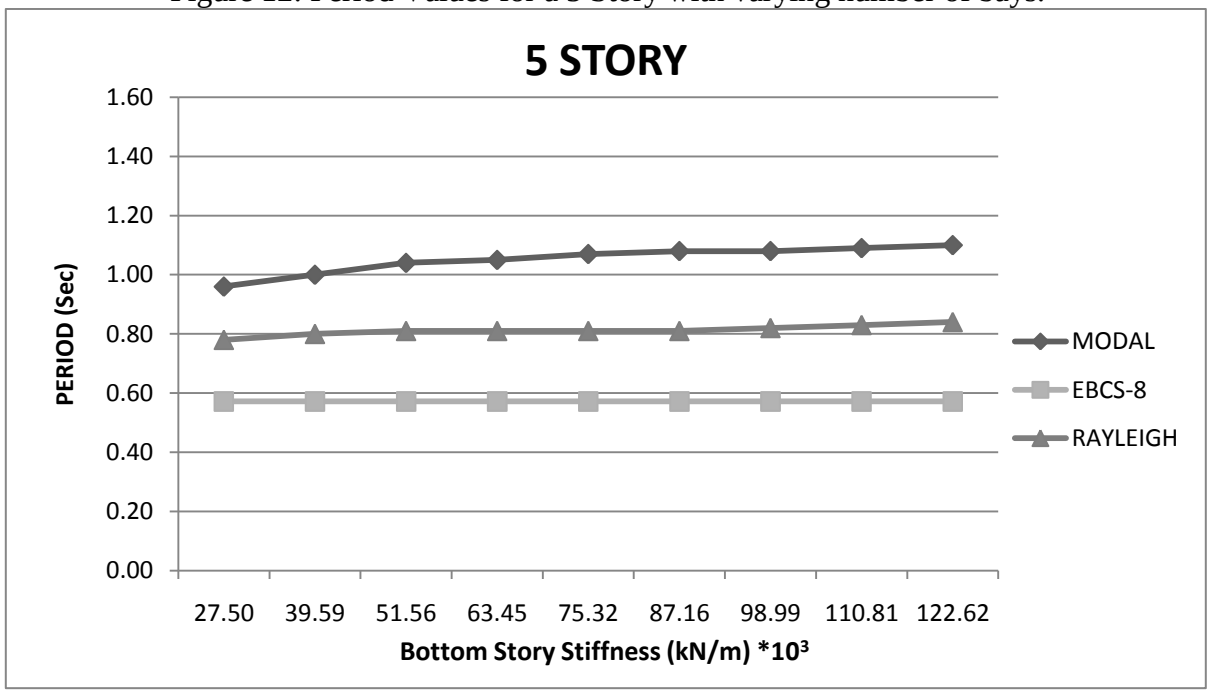


Table xviii above presented period values for a 5 story MRF obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better appreciation of the deviations the results for all the cases considered have also been plotted in graphs shown in Figure 19. It can be seen from the results that an increase in number of bays increases both story stiffness and story mass which caused a minor increase on fundamental period. The period values obtained from EBCS-8 and Rayleigh's formula display little or no difference.

The differences in period between SAP 2000 and EBCS-8 are given in Table xviii for all the cases.

Table xix: Period Values for a 10 Story with varying number of bays.

l	h	p	K_s(bottom) $\times(10^3)$ kN/m	$m_s\times(10^3)$ Kg	T_1 (MODAL)	T_1 (EBCS-8)	T_1 (RAYLEIGH)	% Δ (T_1-MODAL & T_1-EBCS-8)
5	3.0	2	34.23	28.75	0.96	0.96	0.95	-0.15
5	3.0	3	50.28	43.13	1.01	0.96	0.96	4.81
5	3.0	4	66.22	57.50	1.04	0.96	0.97	7.56
5	3.0	5	82.09	71.88	1.06	0.96	0.97	9.30
5	3.0	6	97.94	86.25	1.07	0.96	0.97	10.15
5	3.0	7	113.77	100.63	1.08	0.96	0.98	10.98
5	3.0	8	129.59	115.00	1.09	0.96	0.98	11.80
5	3.0	9	145.40	129.38	1.10	0.96	0.99	12.60
5	3.0	10	161.20	143.75	1.11	0.96	1.00	13.39

Figure 13:Period Values for a 10 Story with varying number of bays.

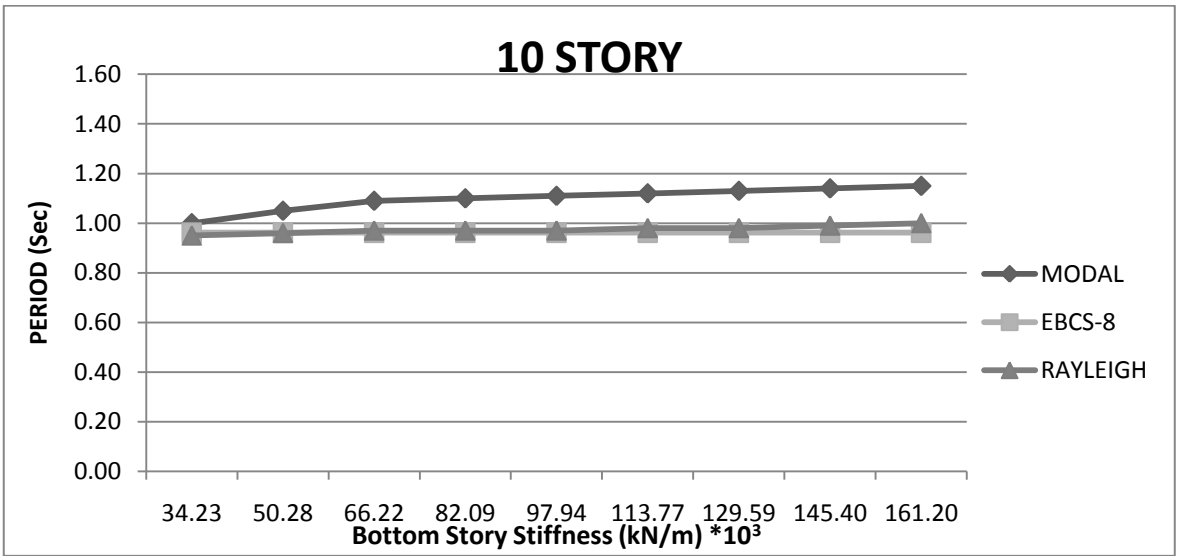


Table xix above presented period values for a 10 story MRF obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better appreciation of the deviations the results for all the cases considered have also been plotted in graphs shown in Figure 20. It can be seen from the results that an increase in number of bays increases both story stiffness and story mass which caused a small increase on fundamental period. The period values obtained from EBCS-8 and Rayleigh's formula display little or no difference.

The differences in period between SAP 2000 and EBCS-8 are given in Table xxiii for all the cases.

Table xx: Period Values for a 15 Story with varying number of bays.

l	h	P	K_s(bottom) $\times(10^3)$ kN/m	$m_s\times(10^3)$ Kg	T_1 (MODAL)	T_1 (EBCS-8)	T_1 (RAYLEIGH)	% Δ (T_1-MODAL & T_1-EBCS-8)
5	3.0	2	37.54	32.05	1.04	1.30	1.16	-25.30
5	3.0	3	55.68	48.08	1.10	1.30	1.17	-18.46
5	3.0	4	73.75	64.10	1.13	1.30	1.18	-15.32
5	3.0	5	91.78	80.13	1.15	1.30	1.19	-13.31
5	3.0	6	109.79	96.15	1.17	1.30	1.19	-11.37
5	3.0	7	127.79	112.18	1.18	1.30	1.19	-10.43
5	3.0	8	145.78	128.20	1.19	1.30	1.20	-9.50
5	3.0	9	163.76	144.23	1.20	1.30	1.20	-8.95
5	3.0	10	181.74	160.25	1.21	1.30	1.21	-7.69

Figure 14: Period Values for a 15 Story with varying number of bays.

Table xx above presented period values for a 15 story MRF obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the deviations the results for all the cases considered have also been plotted separately in graphs shown in Figure 21. It can be observed from the results that an increase in number of bays increases both story stiffness and story mass which caused a minor increase on fundamental period. The period values obtained from EBCS-8 and Rayleigh's formula display a difference while agreeing more with Modal periods.

The differences in period between SAP 2000 and EBCS-8 are given in Table xx for all the cases.

Table xxi: Period Values for a 20 Story with varying number of bays.

l	h	P	K_s(bottom) $\times(10^3)$ kN/m	$m_s\times(10^3)$ Kg	T_1 (MODAL)	T_1 (EBCS-8)	T_1 (RAYLEIGH)	% Δ (T_1-MODAL & T_1-EBCS-8)
5	3.0	2	39.16	35.95	1.09	1.62	1.27	-49.02
5	3.0	3	58.37	53.93	1.15	1.62	1.28	-40.84
5	3.0	4	77.53	71.90	1.18	1.62	1.29	-36.68

5	3.0	5	96.67	89.88	1.21	1.62	1.29	-34.07
5	3.0	6	115.80	107.85	1.22	1.62	1.29	-32.23
5	3.0	7	134.92	125.83	1.23	1.62	1.30	-30.94
5	3.0	8	154.03	143.80	1.24	1.62	1.30	-29.98
5	3.0	9	173.14	161.78	1.25	1.62	1.31	-29.35
5	3.0	10	192.25	179.75	1.26	1.62	1.31	-28.63

Figure 15: Period Values for a 20 Story with varying number of bays.

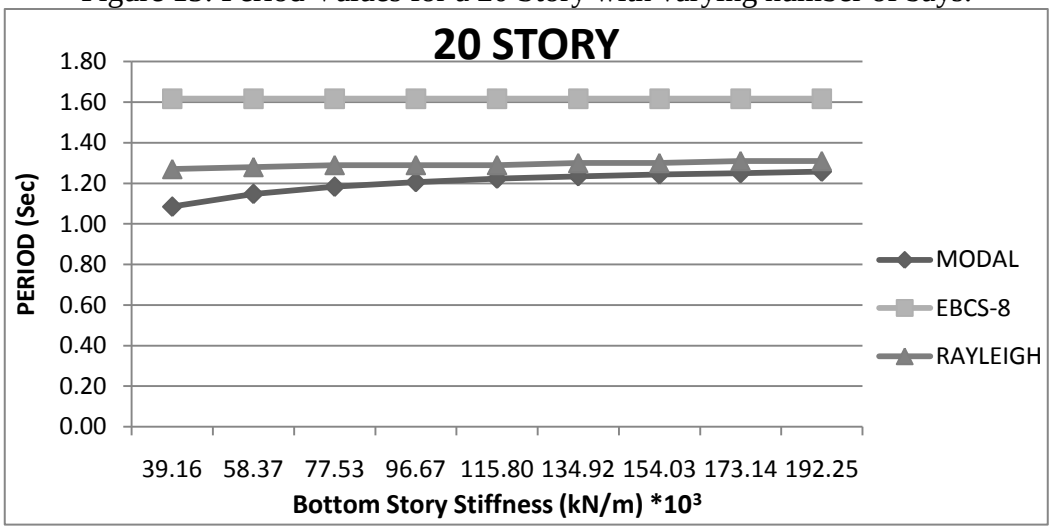


Table xxi above presented period values for a 20 story MRF obtained from modal analysis using SAP 2000 v14, EBCS-8 empirical formula and Rayleigh's formula. For better understanding of the deviations the results for all the cases considered have also been plotted separately in graphs shown in Figure 22. It can be observed from the results that an increase in number of bays increases both story stiffness and story mass which caused a minor increase on fundamental period. The period values obtained from EBCS-8 and Rayleigh's formula display a difference while agreeing more with Modal periods. The differences in period between SAP 2000 and EBCS-8 are given in Table xxi for all the cases.

Table xxii: Effect of number of bay on story stiffness & story mass

3 story		**Top & Intermediate**		**Bottom**			
p	**Δp**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$ (Kg)**	**% m**
2	—	—	44.60	—	41.84	—	50.00
3	1	6.45	—	9.31	—	12.46	—
5 story		**Top & Intermediate**		**Bottom**			
p	**Δp**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$(Kg)**	**% m**
2	—	—	46.34	—	44.00	—	50.00
3	1	7.65	—	12.10	—	13.03	—

10 story		**Top & Intermediate**		**Bottom**			
p	**Δp**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$(Kg)**	**% m**
2	__	__	48.28	__	46.88	__	50.00
3	1	9.03	__	16.05	__	14.38	__
15 story		**Top & Intermediate**		**Bottom**			
p	**Δp**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$(Kg)**	**% m**
2	__	__	49.12	__	48.33	__	50.00
3	1	9.65	__	18.14	__	16.03	__
20 story		**Top & Intermediate**		**Bottom**			
p	**Δp**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**ΔKs, $\times 10^3$ (kN/m)**	**% Ks**	**Δm, $\times 10^3$(Kg)**	**% m**
2	__	__	49.51	__	49.06	__	50.00
3	1	9.95	__	19.21	__	17.98	__

From table xxii above it is clear that for an increase of number of bays from 2 to 3 top & intermediate story stiffness increase by 47.57%, bottom story stiffness increases by 46.02% on average while story mass increases by 50% constantly for all stories considered in this study.

The slight increase of period seen when number of bays increase can be explained by the fact that the % increase in both story mass and story stiffness is relatively close which indicates that the two complement each other with regard to their effect on period. Since period decreases with increase in story stiffness and increases with increase in story mass, an increase in 46.02% of story stiffness is balanced by an increase in 50% of story mass resulting in a few increase of period.

It is observed that for the same overall building height but with different number of bays EBCS-8 formula gives similar (constant) fundamental periods while SAP 2000's output and Rayleigh's formula yield a slightly increasing period values with increase in number of bays.

The findings of this particular investigation are supported by the findings of the research made on the effect of number of bays on fundamental period of MRF RC buildings by Michel S.Chalhouba in 2014which is presented in Chapter 2 of this paper

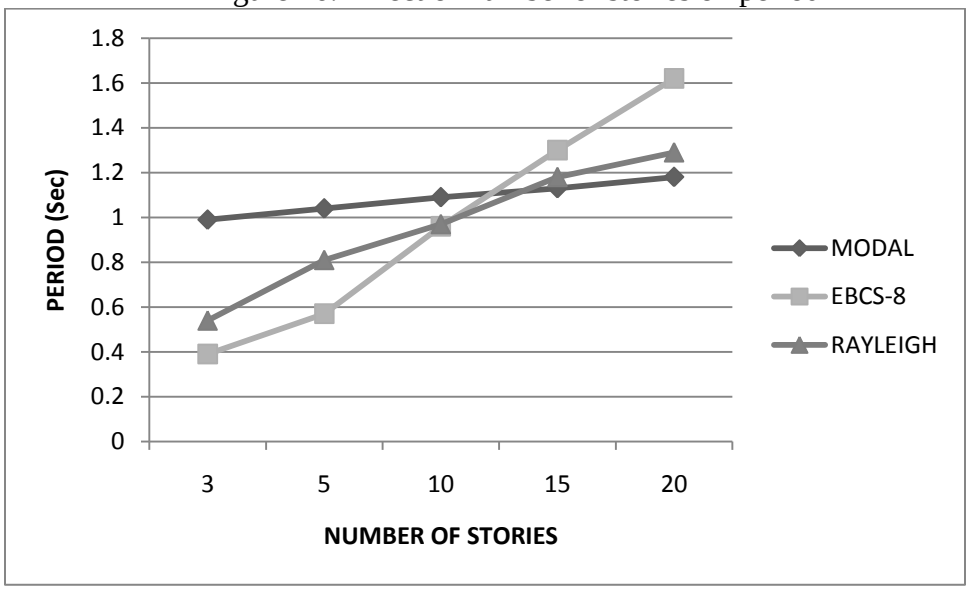
3.2.5 Number of Stories

As seen from the previous analysis results of the parameters the effect of number of stories on fundamental period has been indirectly reflected in every case considered so far.

It can be learned from the results that as the number of stories increase period shows an increase it is also evident that size of columns increase as the number of stories increase from the requirement of gravity load analysis which resulted in increase of both story stiffness and story mass.

The % differences in period between SAP and EBCS-8 outputs are given for all the cases of each parameter.

Figure 16: Effect of number of stories on period



From figure 23 it is clear that period increases with increase in number of stories. Up to around 13 stories both Rayleigh and EBCS-8 formulations tend to underestimate period leading to a conservative estimate of earthquake forces. Above 13 stories EBCS-8 period values are overestimated which translate in to lower earthquake forces compared to modal analysis and Rayleigh's output.

3.3 Expression for Fundamental Time Period

One of the objectives of the present study was to formulate an improved empirical relation to evaluate fundamental time period of regular RC MRF buildings considering different system parameters that have a considerable effect on period beside building height seen in many building codes including EBCS-8.

To this effect SPSS v20 for IBM software was used to come up with a best fit to the modal analysis outputs using multiple linear regressions.

The outline of the multiple linear regression technique is discussed in Chapter 3 of this paper.

The mathematical model used for the regression takes the following form,

$$\mathbf{T_1} = C + b_1\mathbf{l} + b_2\mathbf{h} + b_3\mathbf{s} + b_4\mathbf{m_s} + b_5\mathbf{p} \quad (9)$$

The values for the constant C and the regression coefficients (b_1, b_2,…& b_5)were then calculated using the software.

The statistical outputs are presented as follows,

Table xxiii: **Model Summary**

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.990[a]	.981	.981	.06842

a. Predictors: (Constant), Number of Bays, Number of Stories, Beam Span (m), Column Height (m), Story Mass ($*10^3$) Kg

(*Source: SPSS v20 for IBM software*)

The model summary table above reports the strength of the relationship between the model

and the dependent variable.

R, the multiple correlation coefficient, is the linear correlation between the observed and model-predicted values of the dependent variable. Values closer to 1 indicate a strong relationship.

R Square, the coefficient of determination, is the squared value of the multiple correlation coefficients. It shows that 98.1% of the variation in period is explained by the model (9).

Table xxiv: **ANOVA**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	46.892	5	9.378	2003.191	.000[b]
	Residual	.908	194	.005		
	Total	47.800	199			

a. Dependent Variable: Period (Sec)

b. Predictors: (Constant), Number of Bays, Number of Stories, Beam Span (m), Column Height (m), Story Mass ($*10^3$) Kg

(*Source: SPSS v20 for IBM software*)

The ANOVA table tests the acceptability of the model from a statistical perspective. The Regression row displays information about the variation accounted for by the model. The Residual row displays information about the variation that is not accounted for by the chosen model. As seen in the table the regression sum of squares is considerably larger than the residual sum of squares, which indicates that about most of the variation in Period is explained by the model. The significance value of the F statistic is less than 0.05, which means that the variation that is explained by the model is not simply due to chance.

Table xxv: **Coefficients**

Coefficients[a]

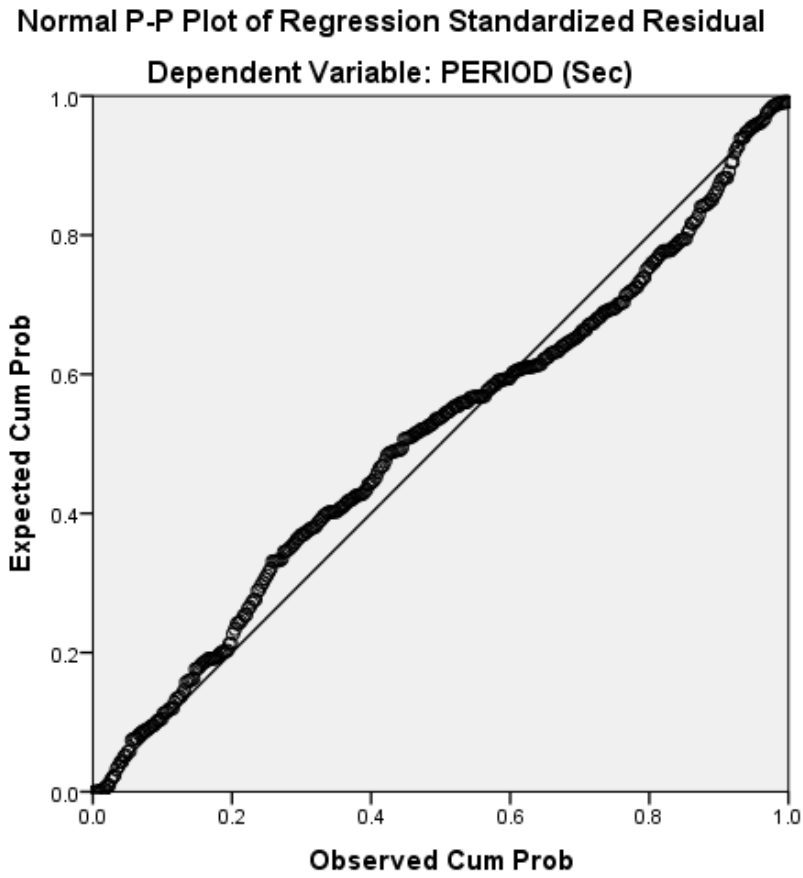
Model		Unstandardized Coefficients		Standardized Coefficients	t
		B	Std. Error	Beta	
1	(Constant)	-.874	.102		-8.581
	Beam Span (m)	.016	.013	.036	1.245
	Column Height (m)	.595	.009	.882	64.601
	Number of Stories	.002	.002	.028	1.042
	Story Mass (Kg)	.008	.001	.452	6.942
	Number of Bays	-.110	.018	-.335	-6.138

a. Dependent Variable: Period (Sec)

(*Source: SPSS v20 for IBM software*)

Table xxv above presents values for the regression coefficients (b_1, b_2….& b_5) in the model which can be seen in the first column of the table. It can also be seen from the table that some of the independent variables do not contribute much to the model. The significance value for those independent variables less than 0.05 indicate a greater contribution to the model.

Figure 17: **Normal P-P Plot of regression Standardized Residual**



(*Source: SPSS v20 for IBM software*)

Figure 24 presented Probability-Probability plots. The observed cumulative probability is plotted against the expected cumulative probability if the data were a sample from a specified distribution. The slope of the plotted points is steeper than the normal line indicating that the residuals show less variability than a normal distribution.

The model can be assumed as linear considering the fact that the residuals have a normal distribution.

The constant C and values for the regression coefficients (b_1,b_2& b_5) in Eq. 9 are,

C = -0.874, b_1= 0.016, b_2= 0.595, b_3=0.017,b_4=0.008 &b_5= -0.110

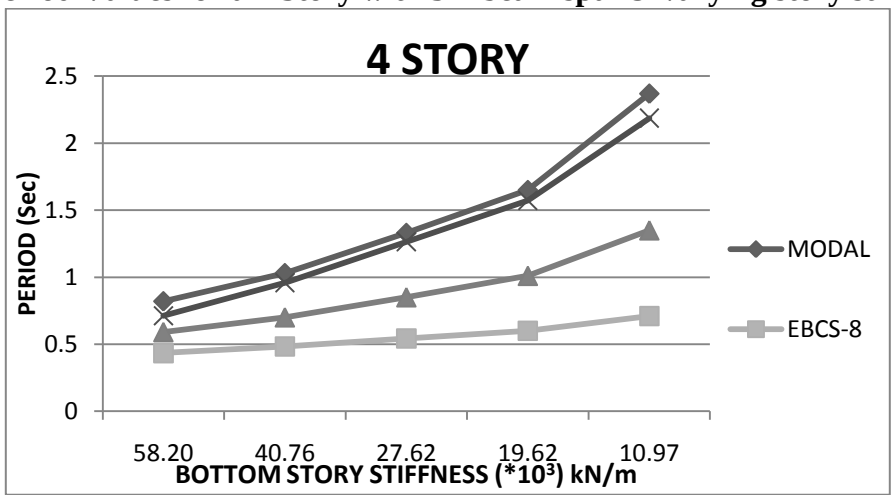
$\mathbf{T_1}$=-0.863+ (0.016×**l**) +(0.595×**h**)+ (0.002×**s**) + (0.008×$\mathbf{m_s}$) + (-0.110×**p**)(10)

The new empirical relation given by Eq. 10 is tested for selected samples, which are used as a control to test the relations and are presented below.

Table xxvi: **Period Values for a 4 Story with 5m beam span& varying column heights.**

l	**h**	**T_1 (MODAL)**	**T_1 (EBCS-8)**	**T_1 (RAYLEIGH)**	**T_1 (EQ-10)**
5	2.6	0.82	0.43	0.59	0.71
5	3.0	1.03	0.48	0.70	0.96
5	3.5	1.33	0.54	0.85	1.27
5	4.0	1.65	0.60	1.01	1.57
5	5.0	2.37	0.71	1.35	2.19

Figure 18: **Period Values for a 4 Story with 5m beam span& varying story stiffness.**



The improved formula given in EQ-10 is tested for each parameter. Table 26 and Figure 25 above portray the variations in period calculated using modal analysis technique (SAP 2000 v14), EBCS-8 empirical formula, Rayleigh's formula and the improved formula (EQ-10) with 5m spanof beam and varying column heights of a 4 story RC MRF. It can be seen in Figure 25 the improved formula presents closer values to the SAP outputs with similar pattern of variation.

The period variation with increase in story mass is presented for a 13 story RC MRF in Table xxvii and Figure 26 below and a better closeness in period between the improved formula and SAP 2000 outputs can be observed.

Table xxvii: **Period Values for a 13 Story with varying story mass.**

Story Mass ($\times 10^3$) Kg	**T_1 (MODAL)**	**T_1 (EBCS-8)**	**T_1 (RAYLEIGH)**	**T_1 (EQ-10)**
64.10	1.11	1.17	1.16	1.09
66.10	1.13	1.17	1.17	1.11
68.10	1.15	1.17	1.18	1.12
70.10	1.17	1.17	1.19	1.14
72.10	1.19	1.17	1.20	1.15
74.10	1.21	1.17	1.21	1.17

Figure 19: **Period Values for a 13 Story with varying story mass.**

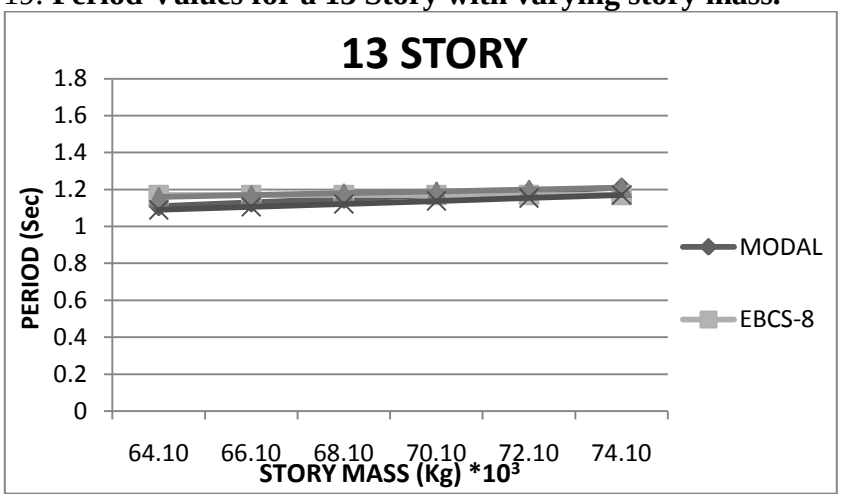


Table xxviii and Figure 27 below reveal the variations in period calculated using modal analysis technique (SAP 2000 v14), EBCS-8 empirical formula, Rayleigh's formula and the improved formula (EQ-10) with varying number of bays for a 22 story RC MRF. It can be seen in Figure 27 the improved formula presents closer values to the SAP outputs and Rayleigh's formula with similar pattern of variation

Table xxviii: Period Values for a 22 Story with varying Number of bays.

Number of Bays	T_1 (MODAL)	T_1 (EBCS-8)	T_1 (RAYLEIGH)	T_1 (EQ-10)
2	1.15	1.74	1.34	1.10
3	1.21	1.74	1.35	1.14
4	1.24	1.74	1.35	1.17
5	1.25	1.74	1.35	1.20
6	1.26	1.74	1.36	1.24
7	1.27	1.74	1.36	1.27
8	1.28	1.74	1.37	1.31
9	1.29	1.74	1.37	1.34
10	1.30	1.74	1.38	1.37

Figure 20: **Period Values for a 22 Story with varying Number of bays.**

4. Conclusions and Recommendations

This chapter presents a brief summary of the research findings discussed in details in Chapter 4 along with significant conclusions and recommendations from this study and for further study.

Fundamental time period of all the selected RC MRF building models were estimated using modal analysis, Rayleigh's method, and empirical equation given in EBCS-8. The results were critically analyzed and are presented in this chapter.

4.1. Summary of Findings

The important findings obtained from the analysis of 200 sample RC MRF building frames are summarized as follows.

1. An increase in both beam span **l,** and column height **h** decreases story stiffness while increasing story mass which ultimately resulted in increase in the time period. More

specifically when column height increases from **3** to **3.5m** bottom story stiffness decreases by **30.62%**; top and intermediate stories also decrease by **29.1%** on average, while story mass increases by **6.2%** on average for all stories considered in this study.

When beam span increases from **3** to **4m**, bottom story stiffness decreases by **17.86%**, top and intermediate stories also decrease by **20.48%** on average while story mass increases by **20.92%** for all stories on average.

The range of increment in period for the parameter column height **h** is found to be more significant than beam span **l**. It is observed that for the same overall building height but with different heights of column and span of beams EBCS-8 formula gives similar fundamental periods while SAP 2000 output and Rayleigh's formula yield different periods.

2. Fundamental time period increases with an increase in additional mass from partition walls and floor finishes. It was observed that when story mass increases by **2000Kg** story mass increases by **3.45%** for all stories on average which resulted in increase of period by **1.85%** on average. It was also witnessed that for the same overall building height but with variations in story masses EBCS-8 formula gives similar (constant) fundamental periods while SAP 2000 output and Rayleigh's formula yield increasing period values with increase in story mass.
3. Fundamental time period increases slightly with an increase in number of bays **p**. It has been seen that for an increase of number of bays from **2** to **3** top and intermediate story stiffness increase by **47.57%**; bottom story stiffness increases by **46.02%** on average, while story mass increases by **50%** constantly for all stories considered in this study. It was also observed that for the same overall building height but with different number of bays EBCS-8 formula gives similar (constant) fundamental periods while SAP 2000 output and Rayleigh's formula yield a slightly increasing period values with increase in number of bays.
4. It is clear that period increases with increase in number of stories. Up to around 13 stories both Rayleigh and EBCS-8 formulations tend to underestimate period leading to a conservative estimate of earthquake forces. Above 13 stories EBCS-8 period values are overestimated which translate in to lower earthquake forces compared to modal analysis and Rayleigh's output.
5. An attempt to provide an improved empirical relation using story mass, story stiffness and number of stories as independent variables and period as a dependent variable revealed that the correlation % between story mass and story stiffness to be 70% which implies that these parameters cannot be considered as independent variables as far their effect on period is considered.

   Therefore an another relationship among the parameters beam span, column height, number of bays, story mass and number of stories is presented separately with period using SPSS v20 for IBM software to come up with a best fit to the modal analysis outputs using multiple linear regressions.

   The values for the constant c and the regression coefficients in the mathematical model used for the regression have been evaluated by the statistical software and it is found out that 98.1% of the variation in period is explained by the model.
6. The new empirical relation has been tested for selected samples of RC MRF buildings and the period values estimated using the new formula show a good resemblance to the SAP 2000 outputs.

4.2. Conclusions

Based on the findings presented in this thesis report, the following item wise conclusions are drawn below:

1. It is concluded that the fundamental time period in a RC regular MRF building is not a function of building height only, which i.e. the influence of important structural parameters on fundamental time period of a regular RC MRF building have not been addressed in EBCS-8 provisions. The simplified code formula, pertaining to total building height, exhibited discrepancies with the modal analysis result and Rayleigh's method results.
2. Based on the findings from the analysis, it can be concluded that fundamental time period is significantly influenced by story stiffness and story mass. It is evident that period increases with an increase in story mass and decreases with increase in story stiffness and vice versa but this fact is not reflected in the EBCS-8 Code.
3. Fundamental time period increases with increasing beam span and column height since an increase in both parameters results in decrease of story stiffness and increase of story mass.

   A variation in column height has more significant influence on story stiffness than a variation in beam span and a variation in beam span has more significant influence on story mass than a variation in column height. This is not accounted in EBCS-8 provisions since it is observed that for the same overall building height but with different height of columns and span of beams EBCS-8 formula gives similar fundamental periods while SAP 2000 output and Rayleigh's formula yield different periods.
4. Considering the outcome of the analysis it is also rational to generalize that fundamental time period increases with an increase in additional story mass due to partition walls and floor finishes. But this is not addressed in EBCS-8 provisions since it is witnessed that for the same overall building height but with additional story masses EBCS-8 formula gives constant fundamental time periods while SAP 2000 output and Rayleigh's formula give increasing periods.
5. Looking at the results of the analysis it is imperative to conclude that fundamental time period increases slightly with an increase in number of bays. The influence of a variation in number of bays on story stiffness and story mass is relatively close with a slight increase in the influence of story mass which resulted in increase of period as number of bays increase. This is not reflected in EBCS-8 provisions since it is seen that for the same overall building height but with increasing number of bays EBCS-8 formula gives constant fundamental time periods while SAP 2000's output and Rayleigh's formula give slightly increasing periods.
6. The study also indicates that period increases with increase in number of stories. Within a range of 3 to approximately 13 stories both Rayleigh and EBCS-8 formulations tends to underestimate the time period leading to a conservative estimate of earthquake forces. More than 13 stories EBCS-8 period values are overestimated which translate in to lower earthquake forces compared to modal analysis and Rayleigh's output.
7. Overall results of the analysis shows that the column height, beam span, number of bays, and story mass when included in the fundamental time period evaluation, yields results that are closer to the exact modal analysis solution than do the simplified code formula given in EBCS-8.
8. Lastly it can be concluded that story mass and story stiffness cannot be considered as independent variables as far as their effect on fundamental period is considered. Since they are inherent properties of structural members changes in parameters affects both.

4.3. Recommendations

4.3.1. Recommendations from this study

(i) It is strongly recommended that it is clearly essential to consider revision of EBCS-8 provisions for calculating fundamental time period of regular RC MRF buildings by considering the important system parameters that greatly influence fundamental period other than building height.

(ii) In addition to the above suggestion it is recommended to use the improved empirical relation obtained from this study by adopting it in EBCS-8 code provisions after assessing its workability especially for preliminary design of building structures for earthquake resistance.

(iii) It is also wise to consider decreasing the 80m building height limit in which equivalent static analysis is allowed for estimating fundamental time period of regular RC MRF buildings in EBCS-8. From the current study it is observed that more than 13 stories (about 40m height) EBCS-8 formula overestimates fundamental time period resulting in lower values of base shear force which has a detrimental effect on structural safety and wellbeing of occupants during an earthquake. Therefore it is recommended to decrease the height limit to about 40m or 13 stories and to suggest the use of dynamic analysis methods beyond 13 stories.

(iv) While carrying out the data collection using questionnaires around Mekelle and Adigrat towns the researcher has noticed that most of the design and consultancy professionals do not consider or have limited knowledge of the effect of the different system (building) parameters on earthquake resistance. Most of the parameters that have been studied in this paper (beam span and column heights, number of bays & stories) are provided in design from the requirements of space, architecture and gravity load analysis only. Considering the fact that these towns are in a high seismic zone it is recommended to give the necessary attention to earthquake effects while providing design values for these parameters.

4.3.2. Scope for further study

(i) The present study was limited to reinforced concrete (RC) multi-storied MRF buildings. There is a further scope for RC multi-storied frame buildings with lateral force resisting systems such as shear walls.

(ii) A similar detailed study can also be conducted on Steel structures.

(iii) This thesis work was also limited to two dimensional frames with lumped mass idealization. There is a further scope for a three dimensional analysis of frames with distributed mass.

(iv) This study did not take into account the soil-structure interaction which has a great influence in seismic response of buildings. Further analysis can be carried out considering soil-structure interaction.

(v) The present study did not consider irregularities with height in both story mass and story stiffness in the frame. Further studies can include this irregularity to study their effect on fundamental period and come up with an all rounded empirical relations.

(vi) The current study is limited to reinforced concrete (RC) multi-storied MRF buildings without infill there is a scope for future study considering infill stiffness.

(vii) Further studies can include effect of T-beams and cracked sections as they are cases present in reinforced concrete design which influence the stiffness of members in particular and story stiffness in general.

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Application of Traditional Ecological knowledge for Sustainable Ecological Restoration- Concepts and Cases

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Abstract

It is the scientific notion that the sustainable features observed in the concept of Traditional Ecological Knowledge can be used as solutions for most ecological issues emerged in the recent decade. The process of preventing the environmental pollution and environmental degradation in order to reinstate the ecological system which is defined as the Ecological Restoration Process is considered as a scientific concept as well as a discipline of applied sciences in the contemporary era on the basis of such ecological issues. This article aims to analyze the application of Traditional Ecological Knowledge in restoring the degraded ecological systems sustainably with reference to recent researches. Further, the article serves to determine the possibility of converting scientific restoration methodologies into sustainable restoration methodologies by making the experiential knowledge in the context of Traditional Ecological Knowledge overlapped with the ecological restoration concept which is considered as a scientific perspective.

The compositions of those concepts, experience of the Asian region and differences in the application of them in Sri Lankan context have been mainly focused in this study. Sustainable ecological restoration methodologies are mostly explicit in the traditional knowledge of Sri Lanka and South Asia which claim to have the highest bio-diversity and a cultural history while there is a possibility of minimizing the environmental degradation and restoring the degraded ecological systems through using those methodologies under a scientific and culturally flexible perspective.

Key Words: Traditional Ecological Knowledge, Sustainable ecological restoration, Degradation

1. Introduction

The concept of traditional ecological knowledge (TEK), along with synonymous or closely related terms like indigenous knowledge and native science, has some of its origins in literatures on international development and adaptive management. There is no universally accepted definition for traditional ecological knowledge (TEK). In the literature it is defined as an ambiguous term which has many theoretical arguments. Societies and cultures have been changing through the time and the space. Temporal and the spatial pattern of the living area influence the human adaptation to their surrounding or environment. Because of those experiences which have been taken from the environment, a unique knowledge about the eco system of the surrounding area is built. That kind of spatial knowledge about the environment can basically defined as a traditional ecological knowledge.

Many scholars prefer to identify TEK as a collaborative concept. Because of that many kinds of dissimilarities occur in the definitions of the TEK.

Traditional ecological knowledge refers to the knowledge, practice and belief concerning the relationship of living beingsto one another and to the physical environment, which is held by people in relatively non-technological societies with a direct dependence

upon local resources (Berkes 1993)

Traditional ecological knowledge is not unique to Native American culture but exists all over the world, independent of ethnicity. It is born of long intimacy and attentiveness to a homeland and can arise wherever people are materially and spiritually integrated with their landscape (Kimmerer 2000).

This long intellectual tradition exists in parallel to Western science, yet has been historically marginalized by the scientific community (Salmon 1996).

Mainly these definitions prove that the native knowledge is a strong tool to identify the novel scientific themes. Because of these comparisons of the TEK and SEK, most of the scientists try to distinguish these topics. Traditional knowledge has much in common with scientific ecological knowledge (SEK), which is not surprising since both traditions derive from the same source: systematic observations of nature. Both knowledge systems yield detailed empirical information of natural phenomena and relationships among the ecosystem components. Both SEK and TEK have predictive power, and in both intellectual traditions, observations are interpreted within a particular cultural context. TEK is being recognized as having equal status with scientific knowledge (UNEP 1998)[1].

FikeretBerkes (1993) has mentioned that there are 9 differentiations of the TEK from the SEK.

TEK	SEK
Mainly qualitative.	Mainly quantitative.
Possesses an intuitive component.	Purely rational.
Holistic.	Reductionist.
Mind and matter are considered together.	A separation of mind and matter.
Moral.	Supposedly value-free.
Spiritual.	Mechanistic.
Based on empirical observations and accumulation of facts by trial-and-error.	Based on experimentation and systematic deliberate accumulation of fact.
Based on data generated by resource users themselves.	Based on data generated by a specialized cadre of researchers.
Based on diachronic data, i.e., long time-series on information on one locality.	Based on synchronic data, i.e., short time-series over a large area.

Traditional knowledge encompasses a wide range of biological information, which overlaps significantly with the content of a mainstream course in ecology or conservation biology. The scope of traditional ecological knowledge includes detailed empirical knowledge of population biology, resource assessment and monitoring, successional dynamics, patterns of fluctuation in climate and resources, species interactions, ethno taxonomy, sustainable harvesting and adaptive management and manipulation of disturbance regimes (Berkes1999).

2. Characteristics of traditional ecological knowledge

Characteristics of traditional ecological knowledge (TEK) have been investigated by many researchers and the following paragraph has summarized the main characteristics and how those characteristics have been explained.

TEK adopts a more holistic approach, and does not separate observations into different

disciplines as does western science (Mazzocchi, F., 2006). Moreover, according to the Freeman (1992) TEK systems do not interpret reality on the basis of a direct cause and effect, but rather as a world made up of complex web of interactions. Some of these TEK are based on their religion and even based on super natural incidents as well. These quantities may not be able to either measure or compare or even these may not be tangible (Sharma &Pegu, 2011). According to Somasundara (2006) TEK is mainly based on cognitive, ideational and social environments.

According to Clarkson et al. (1992); Berkes (1993); Doubleday (1993); Tyler (1993); Wavey (1993); Mitchell (1994), other common characteristics of traditional ecological knowledge are as follows;

- Knowledge is gained through intimate contact with the local environment, while noting patterns or trends in its flora, fauna and natural phenomena. It is based on data collected by resource users through observation and hands-on experience referred to as qualitative.
- Knowledge is transmitted by oral tradition.
- Social context that sees the world in terms of social and spiritual relations among all life forms which manifeststhatall parts of the natural world are infused with spirit. Mind, matter and spirit are perceived as inseparable referredtoas spiritual.
- Promote balance and harmony between the well-being of the individual and the well-being of the social group referred to as mutual well-being, reciprocity and cooperation.
- Views time and processes as cyclical refers as non-linearity.

According to the above statements, the holistic view or approach compared to cause and effect view can be identified as the main characteristic of Traditional Knowledge. Also it has been identified asthis knowledge cannot be measured or compared with current scientific methods. The qualitative, nonlinearity, spiritual and mutual well-being, reciprocity and cooperation can be identified as the key significant characteristics. Although the above characteristics have directed traditional knowledge towardsmore of practical knowledge, it is not possible to simply reduce TEK to practical knowledge that is exclusively based on experience as opposed to theoretical knowledge, which is developed through deductive or inductive reasoning.

3. Ecological restoration

This refers to the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. Although the idea of ecological restoration is introduced as a field of Biology in 1980, it is being practiced by community over thousands of years. This has strong linkage with TEK as well. Most of the TEK on agriculture focuses on agro productivity coined with ecological balance and restoration.

Ecological restoration is mainly based on approaches of Sustainable Ecology, Cultural Ecology and Sustainable Adaptation Ecology. Restoring or recovering the damaged, degraded or disturbed environmental systems without compromising sustainability of human kind and ecological balance of the environment can be defined as Ecological restoration (Douterlungne*et al.*,2010).

In most of sustainable development projects, environmental conservation projects, the requirement of sustainable interrelationship between human and environment which arises from the ecological restoration is a vital fact and it is necessary to enforce rules or mechanisms to secure it.

The above concept of ecological restoration can be stated in five steps.

1. Understanding the ecological system.

2. Understating the ecological process.
3. Identifying the disturbances and damages of the ecological system.
4. Restoration of ecological system caused by the above disturbances or damages.
5. Adapting to the restored ecological system.

Restoration of endangered species types, Restoration or conservation of bio-diverse eco systems and Restoration of cultural or environmental habitats are few common examples for ecological restoration. Among these ecological restoration & sustainability concepts, the restoration of agricultural systems and ecosystems which falls under restoration of cultural or environmental habitats becomes a higher priority due to direct relationship of agriculture and in human sustainability.

With regard to agricultural ecological restoration, following methods are widely used around the world for various restoration processes.

- Reforestation and re-vegetation to minimize soil erosion.
- Day lighting streams.
- Remove of non-native species and weeds.
- Reintroduction of native species.
- Habitats and range improvement for targeted species.

Upretyet *al* (2012) believes that the ER mainly depends on two approaches: scientific approach and multidisciplinary approach. Scientific approach mainly coordinates with scientific subjects including Biology and Geology, Chemistry, Climatology, Soil Science, etc.

As the Multidisciplinary approach, social, cultural, physical and spiritual contexts are the key areas which will coordinate the ecological restoration. Approach tries to coordinate cultural and social environment with physical environmental conditions and spiritual contexts of a society for ecological restoration. TEK for ecological restoration is a vast area which comes under this multidisciplinary approach.

There are three main arguments which have been stated by scholars about usability of TEK. Those arguments give an important idea about the method which can be used to overlap the scientific system of ER and the TEK. Localization, ethical consideration and adaptation. According to localization argument, some of the scientists have different opinion due to inherited nature of TEK. Since TEK is not fully scientifically sounded or understandable, some of the scholars have been skeptical about the usability of this knowledge beyond limited region (Hobbs & Harris, 2001). Acording to Mazzocchi(2006), TEK contains mysterious rituals, beliefs, folk tales, etc. which are hard to justify with modern scientific methods and indistinct information available about the origin of this knowledge questions many methods of traditional knowledge.

According to ethical consideration, many scholars concern on the ethic of exploiting or exploring these culturally related things for the academic or policy purposes.Bell*et al*., (1997) believes that by investigating, verifying or challenging their cultural identities, landmarks will harm or disrupt their cultural sustainability, etc. They propose to conserve the TEK.

According to the adaptation argument, scholars have stated that science is not a medium which can fully understand the TEK. They believe that understanding of TEK should be based on the perception of traditional people. This concept has been used by Gariboldi&Turneer() to understand the usability and the outcome of the TEK. In their study, they have used this adaptive method to identify the keystone species in Canada. As mentioned above, though there are peeks and falls in use of TEK, it is important to account TEK for

better ER and investigate TEK without harming or disrupting the culture which it resides. When considering the name "TEK", although there are some differences in the terms, indigenous knowledge, traditional ecological knowledge, traditional ecological knowledge and wisdom, traditional environmental knowledge, local ecological knowledge, etc. theyrefer to the same context in many materials (Hobbs. and Norton, 1996).

Understanding limits of the modern science and how TEK can extend those limits is important. This can be explained in two ways. The modern science or scientific method requires practical experiences or incidents to construct a hypotheses or model. Since these experiences or incidents are rarely constructed in lab environment, scientists mainly rely on investigated phenomenon observed by real world. Though modern science evolves continuously, it requires above phenomena or observations to expand its limits. Since TEK contains enormous amount of observations, mechanisms and methods, this gives rise to new models, hypotheses, etc. for modern science (Mazzocchi,2006).

As of the second point, due to inheriting nature of the TEK, the mechanisms and methods contained in it had been evolved for centuries and due to these iterative processes TEK consists of previously gathered ecological data by providing concordant and additional information at a finer geographic scale than scientific data. The limited ability of modern science to deal effectively with environmental issues of increasing magnitude and complexity can be comprehended much easily with above data (Mazzocchi,2006).

In 1980, Restoration ecology has been introduced as the scientific study for supporting ER practices. Restoration ecology is also introduced as the academic study of the process of ER. This concept mainly comes under conservation biology and it alignswith scientific study protecting and restoring bio-diversity. Some researchers believe that restoration ecology provides effective conceptual and practical tools for restoration of ecosystems (Hobbs & Harris, 1996). They argue that restoration ecology has to be an integral component of land management as well. Apart from the common theme of "scientific study", some of the researchers have explored on various other fields where there are interconnections between restoration ecology such as landscape ecology and cultural ecology,etc. (Bell *et al*., 1997).

Although many researchers have taken various paths, almost all the researches are based on two fundamental concepts, which are namely "ecosystem health" and "ecosystem integrity" [SER 2002]. There are four main key processes which Hobbs&Nortan (1996) have depicted.

I. Identifying and dealing with the processes leading to degradation,
II. Determining realistic goals and measures of success,
III. Developing methods for implementing the goals and incorporating them into land-management and planning strategies,
IV. Monitoring the restoration and assessing its success (Hobbs &Nortan,1996).

This research mainly set to examine the first three processes.

3.1 Goals of ecological restoration

This can be linked with the above-mentioned restoration ecology; that these goals can be identified as the conceptual goals derived from restoration ecology models. When the ER goals are considered, many researches and organizations have identified various goals which cover many aspects of the ecosystems. They are,

I. Improvement of biological diversity in degraded landscapes,

II. Increment of the population levels and widening the distribution of rare and threatened species,
III. Enhancement of landscape connectivity,
IV. Increasing the availability of environmental goods and services, and contribution to the improvement of human well-being

These are considered as the key goals(SERI & IUCN, 2004). As shown in Figure 01, for a successful ecological restoration there should be a combination of economic, environmental and social sustainability.

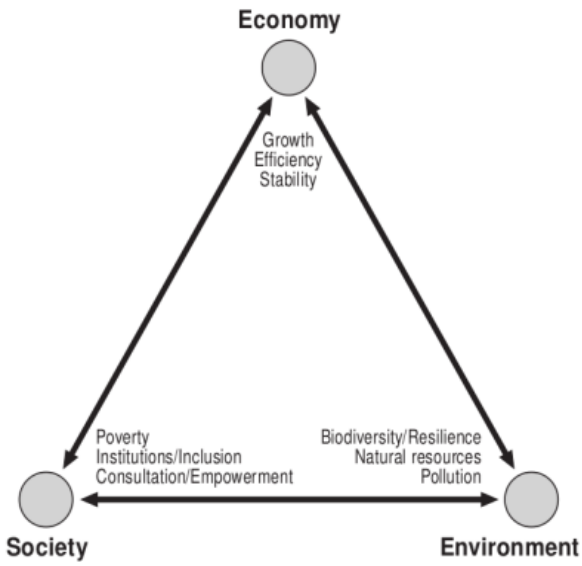

Figure 01: The relationship between social, economic and environmental sustainability (adapted from Jepma & Munasinghe, 1998)

As a single rigid goal of ER, the return of an ecosystem to its pre-disturbance state could be identified and it is believed that the knowledge of historic conditions is the starting point of restoration design (Kimmerer, 2000; Egan & Howell, 2001; Lamb *et al*., 2005).

3.2 Reference eco-system

In ER, it is important to understand how restoration ecologists measure their success and how they identify the degraded ecosystems. Both of the above ideas need a reference eco system, which can give a basic reference to an ideal ecosystem. Determination of reference conditions or reference ecosystem becomes the central component of ER (Higgs, 1997). The reference ecosystem provides a model to follow and is also used as a standard for evaluation and monitoring (Meffee& Carroll, 1994). Finding a reference ecosystem can be done either by a predictive basis or a historical basis. Predictive basis is mainly based on scientific methodologies dealing with concepts of sustainability. Although predictive basis methodologies are more aligned with ER scientific approach for constructing reference ecosystems, TEKand historical information play vital roles in the determination of the reference eco system for both methods. In this study, a concept of reference eco system will be examined in respective villages and TEK will be the main factor which is going to be utilized for construction of reference eco system.

An ecosystem is mainly based on the composition of existing animal species, forestry and landscape. Many ecologists believe that the site selection for restoration plantation is as important as species selection (Shebitz, 2005). According to Higgs et al (2014),amodel of

temporal and spatial scales encompassed by historical-ecology data can be described as follows.

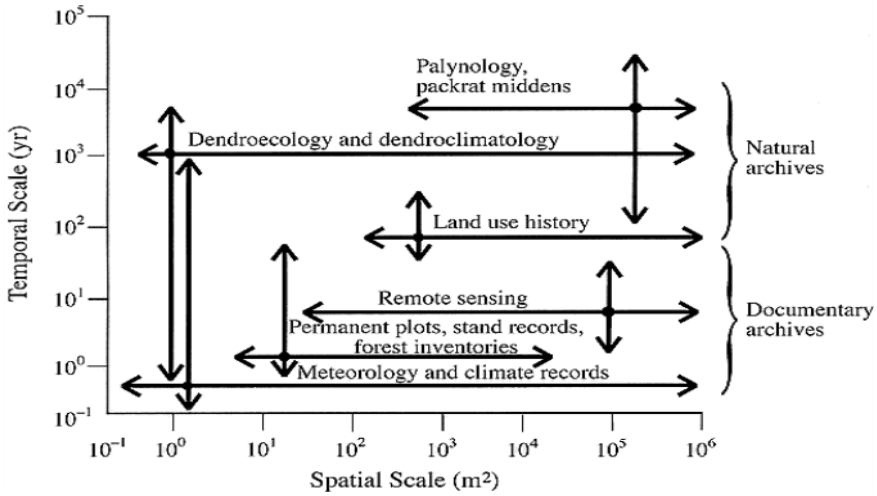

Figure 02: Model of temporal and spatial scales encompassed by historical-ecology data

According to Higgs et al (2014), this study prefers to refer documentary archives for deriving historical information and knowledge for the reference eco system.

3.3 Relevance of history to restoration ecology

As mentioned in reference ecosystem selection, the history of the region gives a basic overview of the native species, landscape and cultural identities. Various sources of historical feature events and incidents reveal future of the regional landscape, cultural characteristics, environmental conditions, climatic information, etc. Identifying this information and knowledge gained from it can be used for several aspects of ER. Accordingly, history as information and reference, history as enriching cultural connections and history as revealing the future are identified as some guidelines for ER (Higgs *et al.*, 2014).

As information and reference, it is directly related to the classical ER definition "ecological restoration attempts to return an ecosystem to its historic trajectory" (Society for Ecological Restoration, 2004).Word historic trajectory gives the meaning of past state of the ecosystem. This is directly linked with historical information and reference with regard to the time-line of the region.

Historical knowledge strongly reinforces the sense of history as place. Glassberg (2001) introduce the second aspect of history as an enriching cultural connection. The knowledge of history not only produces maps of land use, but also what people actually did on the land, what they thought about it and how they coped with crises. A critical connection to that landscape (Allen, 2002) gives a holistic view of an ideal ecosystem which can be referred as a reference eco system.

With regard to history as revealing the future, an unexpected outcome of identifying different kinds of historical knowledge can be used to reveal potential future conditions of the eco system. Historical studies can help make predictions based on similar occurrences and give guidelines for cautious steps that need be taken.

4. Concepts of Ecological Restoration in Traditional Ecological knowledge

Although there is some overlap between ER and Traditional Ecological Knowledge, they are basically two different fields. ER has been one of the most important topics in environmental science since 80s. Restoration ecology, goals of ER, reference eco system,

relevance of history in ER and restoration vs. rehabilitation can be found as the most important concepts in the context of ER in this research. Measuring ER using traditional ecological knowledge, localization and validation of traditional ecological knowledge, are the mainly focused concepts in TEK.

4.1 Relating traditional ecological knowledge **to ecological restoration**

TEK is defined as a cumulative body of knowledge, practice and belief that evolves by adaptive processes and handed down through generations by cultural transmission, and centers on the relationships of humans with one another and with their environment (Berkes, Colding, and Folke, 2000). Examples of TEK include: impacts of historical land loss on affected communities, changes in flora and fauna, natural resource use and degradation of those resources over time, a history of man-made structures and impacts on the ecosystem and community and the identification of priority areas of community significance or concern. A substantial body of TEK exists in traditional communities, particularly in the traditional groups that have historically lived in theirown forests and made their living directly from the ecosystem services offered by those forests. That source of information is virtually unused in the restoration planning process. There are evidences that restoration managers and scientists have started to recognize the value of incorporating TEK into ER.

4.2 Measuring ecological restoration using traditional ecological knowledge

TEK has been found to be an effective and efficient method for the monitoring and assessment of restoration projects (Monela*et al.,* 2004). Most traditional monitoring methods used by indigenous cultures are rapid, low-cost and easily comprehensible (Moller *et al.*, 2004). Monitoring resource status is a common practice among many indigenous or traditional people, and it is often accompanied by the monitoring of ecosystem changes (Berkes, *et al.* 2000). Local people observe day-to-day changes and are among the first to notice if resources are no longer readily available (Berkes*et al.,* 2000). Potential value of TEK for the management of natural resources was identified by several organizations that are in belief that it might be useful in conservation of education as well as in development planning and environmental assessment (World Conservation Union, 1986).

Traditional ecological knowledge based monitoring methods are useful in ecosystem monitoring and timely planning resource allocations and reinforcements, before resource reaches a critical level. In particular, TEK can provide information about the spatial and temporal distribution, composition,health, condition and behavior of many species and the factors that affect them (Stevenson, 2005). It can also provide information about the trajectory of the restoration, disturbance factors and further interventions, if necessary, at low cost and with little delay. Monitoring not only enables ecological bodies to determine if the objectives of the restoration are being met, it also provides information on the capacity of the restored ecosystem to supply desired goods and services to the local people.

In this research, the concept of **measuring ecological restoration using traditional ecological knowledge will be employed and agricultural TEK**monitoring systems of the Knuckles region will be examined.

4.3 Localization

When considering TEK, it is important to understand that ecological knowledge may be localized in specific areas or regions. The validity or the methods may only work relevant to the area or regions. This concept should be incorporated in this study to investigate TEK methods relevant to different ecological conditions to derive effective TEK related ER.

4.4 Validation of traditional knowledge

Cultures from all over the world have developed different views on nature throughout human history. Many of them are rooted in traditional systems of beliefs, which indigenous people use to understand and interpret their biophysical environment (Iaccarino, 2003). It is not possible to simply reduce them to practical knowledge that is exclusively based on experience as opposed to theoretical knowledge, which is developed through deductive or inductive reasoning.

Western science is deeply rooted both in the philosophy of Ancient Greece and the Renaissance, and TEK systems have radically developed different strategies to create and transmit knowledge. Most of the scientists believe that, it is exceedingly difficult to analyze one form of knowledge using the criteria of another tradition (Mazzocchi,2006).

Scientific method favors analytical and reductive methods as opposed to the more intuitive and holistic view often found in TEK. Western science is seen as positivist and materialist in contrast to TEK, which is spiritual and does not make distinctions between empirical and sacred (Nakashima &Roue, 2002). Furthermore, Western science is objective and quantitative as opposed to TEK, which is mainly subjective and qualitative. Western science usually isolates its objects of study from their vital context by putting them in simplified and controllable experimental environments which also means that scientists separate themselves from nature, the object of their studies; by contrast, TEK always depends on its context and particular local conditions (Nakashima & Roué, 2002).TEK systems do not interpret reality on the basis of a linear conception of cause and effect, but rather as a world made up of constantly forming multidimensional cycles in which all elements are part of an entangled and complex web of interactions (Freeman, 1992).

From the above brief comparison, it gives an understanding of how hard it is to compare the two systems of knowledge that are so profoundly different. Trying to analyze and validate TEK systems by using scientific criteria carries the risk of distorting such systems in the process. At the same time, scientists or valuators cannot extract just those parts of TEK that seem to measure up to scientific criteria and ignore the rest.

TEK seems to be better suited to cope with the uncertainty and unpredictability that are viewed as intrinsic characteristics of natural systems. Western science and TEK constitute different paths to knowledge, but they are rooted in the same reality.

This indicates that, though verification and validation of TEK is tedious, the concepts and ideas of TEK can be useful for the humankind. Traditional ecological knowledge that comes in many forms such as rituals, folk tales, gossips, etc. can be a good source for gaining new insights and ideas for real life problems. In this study,TEK can be validated using traditional methods which have been identified by the people who have been living there for many years.

5. Application of ecological restoration using traditional knowledge: South Asian experience

As the third part of this chapter, application of ER using traditional ecological knowledge is discussed. As mentioned in part two, it is known that TEK can be used in ER assessment, site selection, identifying key stakeholders of the eco system, etc.

The researches which have been carried out relevant to this study have been described below. The South Asian region has more similarities with Sri Lanka in both environmental and cultural aspects and it is believed that it might have some similar characteristics which may have good resources for the study.

Acording to Ghimier*et al*. (2008), Himalayan medicinal plants are threatened by over-harvesting for trade. They have analyzed the effects of harvesting patterns on the population ecology of two highly endangered Himalayan medicinal plants, *Nardostachysgrandiflora* (Valerianaceae)
and *Neopicrorhizascrophulariiflora* (Scrophulariaceae) in Shey-Phoksundo National Park and in its buffer zone in North-Western Nepal. They have first recognized local harvesting approaches of two main user groups: *amchi* (traditional doctors trained in Tibetan medicine), who harvest plants in a selective manner for local health care purposes, and commercial collectors, who harvest at much higher intensity for trade. Grimier et al. have applied the selective harvesting approach of *amchi* in an experiment to test the effects of different harvesting levels on the population ecology of two species. In this sector,Rotation harvesting method applied by local people was investigated by the scholars. Traditional knowledge about harvesting and the sustainable usage of the land has been mainly considered by Ghimier et al. (2008) According to TEK rotation, harvesting provides enough time to restore population in old harvested sites. Their experiments revealed a positive effect of low harvesting levels on plant density, but recruitment and survival rates decreased with the increasing harvesting levels. They also analyzed the effect of high harvesting pressure for trade on the population ecology of *N. grandiflora*. Recruitment and survival rates were higher in *N. scrophulariiflora* than in *N. grandiflora*; the latter species is more vulnerable to harvesting than the former. The difference between them in sustainability of harvest is related to differences in their strategies of vegetative reproduction and in harvesting practices associated with these strategies. According to Ghimier et al. (2008), management of Himalayan medicinal plants can be improved by taking harvesting patterns, plant life forms and growth patterns into consideration. This research has mentioned that TEK harvesting methods are more sustainable than the new methods and they have subjected that TEK methods can be used for ecological restoration in the Himalayan region.

Another research carried out by Ramakrishnan (2007) on Traditional Soil Fertility Restoration Practices was used to restore soil fertility from erosion or leaching. In this study Ramakrishnan tried to come up with forest management techniques to restore forest ecology by combining modern conservation mechanisms with traditional knowledge gathered by forest inhabitants.

5.1. Traditional knowledge practices in Sri Lanka- Potentials to the sustainable ecological restoration

TEK had been developed with the civilization of Sri Lanka. When analyzing TEK, it is important to consider the evolution of local civilization. As started in, Indian and local literature from the era of king "Ravana ", it is believed that a unique knowledge had been existed and it had been passed down from one generation to another (Ananda&Nahallage, 2014; ,Knighton, 2013). Along with the "Mahindagamanaya" in 250 BC, this unique knowledge had been re-engineered and left with many rituals embraced with Buddhist philosophy. Not only that, due to strategic location of the island in the world such as being in the silk root, several knowledge channels from western to eastern had been shared among the natives. Since this mixing of knowledge happened in localized manner, the enhancements of local TEK took a regional-based differentiation. Coastal area (Amarasinghe*et al.*,1997), dry land (Ulluwishewa, 1991,1995) and highland area or the hill areas (Daskon&Binns, 2009) had been identified as the main regions which had their own knowledge systems and practices.

Among all those TEK systems and practices, agricultural knowledge (Ulluwishewa, 1991,1995, Ananda&Nahallage, 2013), irrigation technologies (Geekiyanage&Pushpakumara, 2013), traditional medication, architectural knowledge and mathematical knowledge were functioned up to 15th century. Remaining of ancient tank systems, ancient irrigation systems, remnants of buildings and other equipment recovered in archaeological sites are proofs for the vast TEK systems existed in Sri Lanka.

In the present study, the main interest in on TEK or traditional ecological knowledge relating to agricultural practices. There can be two main types of knowledge or practice types in agriculture; i) Physical knowledge and ii) Arcane knowledge.Physical knowledge includes all knowledge based on precipitation, nature of the soil structure, topography and species diversity.

The physical knowledge is separated as knowledge of pre-irrigation era and knowledge of post- irrigation era. The pre-irrigation knowledge had been long lost and the remaining parts are integrated to post-irrigation knowledge with enhancements.

Irrigation technology can be considered as the major turning point in ecological knowledge in agriculture where it organized knowledge in systematic manner and gave an opportunity to enhance the knowledge over the iterations. The tank technology, dam building mechanisms, canal systems and water management are the major knowledge parts. Harvesting of large areas of dry land with limited amount of water is one of the best examples showing how productive those traditional water management techniques were (Geekiyanage&Pushpakumara, 2013).“Bethma” method, “Kekulan” method (Upawansa, 1997)“Pangu” method,etc. are some other examples for the existence of physical agricultural TEKinSriLanka (Karunaratne&Herath, 1989, Wills-Johnson, 2004).

Each of these methods has unique way of managing water and land quality. Bethma method used tank water for paddy fields which led to optimize the usage of seasonal rain water, where excess water in rainy season was stored and utilized in dry season. This ensures continuous harvesting as well as eco system protection in dry season. Alternative plantation of rice and gathering is known as Kekulan method and Karunaratne&Herath (1989) believed that Kakulan ensured the quality of soil through adding micro nutrients to the soil system.

Traditional agricultural knowledge not only focused on harvesting, but also there are many evidences for using this knowledge in land use techniques, water management techniques and bio- diversity maintenance techniques that enhanced the eco system continuity and possesses (Geekiyanage&Pushpakumara, 2013).

Some scientists believe that Sri Lankan TEKhad a spiritual philosophy (Dharmasena, 2010). The Sri Lankan agri-technology can be described in three extensive processes:bio-agriculture (physical structure of plantation, maintenance and harvesting), socio-cultural process and spiritual philosophy (Senaviratne, 2001).

Traditional native farmers maintained sustainability via eco system continuity and ecological balance. The key concepts of TEK can be identified as working with the eco system and utilization of agricultural methods/environmental strategies which were parallel and compelled with existing ecosystem. Traditional people have identified over the generations, that practicing of eco system friendly strategies and methods prevents environmental issues such as disasters and hazards (Geekiyanage&Pushpakumara, 2013, Ulluwishewa, 1991).

According to Senaviratne (2001), Sri Lankan traditional farmers’ spiritual philosophy can be explained in three categories: astrology or constellation based spiritual philosophy, god

and spirits based spiritual philosophy and charms, spells, amulet and symbols or emblems based philosophy.

In TEK, influence to the eco system by astrological objects such as solar systems, constellation, etc. has been described by astrology. In traditional agricultural practices from seed plantation to harvesting, almost all the main activities were identified as auspicious activities and all of them were commenced according to astrology. According to Jayaratne (1997), native Sri Lankans had enormous unique knowledge on astronomy and it provided the base and accuracy for the above astrological activities.

The incidents that could notbe explained by general perceptions were explained using god and spirit concepts. The concepts of "Gopaludevi" (God supreme to cows) and "Gopaluyaksha" (Demon supreme to cows) are examples for those and some of the scientists believe that those "hyper-physical" activities may have some truth that the modern science could not explained yet. Traditional folks believed that worshiping gods' statues, shrines and sacrifices or offerings to gods were the basic methods to overcome those hyper-physical activities or to get favors (Kariyawasam, 1986) from those activities. "Muttinememma" ceremony is one of the best examples that can be seen even in modern days.

For charms, spells and amulets, "pirith" was used and these kinds of traditional habits are still functioning in rural areas. In Agricultural activities, amulets and "kem" methods are used and most of these methods are based on gods or spirits. Amulets are basically worn as a protection mechanism and for agricultural lands; these amulets are hidden in each corner of the lands. Sometimes it symbolizes the binding of some sort of spirits to the amulet and for each of these charms it contains unique regulations for the user and once the regulations are violated it is believed that the power of the charm or amulet will be weakening (Senaviratne, 2001).

Spells are mainly based on vocal patterns, rhythms and verbal patterns. It is believed that those rhythms and patterns contain special powers. The wild elephants controlling spells can be introduced as one of the best examples for these kinds of spells which contain such a rhythm and pattern.

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The Future of Organic Electronics: Small Molecules and Conducting Polymers

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Organic semiconductors represent new class of active materials for electronic applications. This paper traces the history of organic semiconductors including conducting plastics. The fact that organics popularly called plastics, could carry current started gaining currency in 1950s. Several small molecules namely polycyclic aromatic compounds under suitable doping conditions exhibited conductivity upto 1S/cm. Although conductivity was reported in polyaniline in 1862, concrete report of conductivity in doped polymer – polyacetylene – emerged from Shirakawa's Lab in 1977. The 2000 Nobel for this discovery went to Shirakawa, Heeger and MacDiarmid and was really a culmination of long-standing recognition that was due to these materials. With the discovery of electroluminescence in polymers by Robert Partridge, the devices with polymers were on the horizon. In 1987, the first organic diode was produced at Eastman Kodak by Twang and Slyke, setting the stage for the present day design of Light emitting diodes based on organic materials, abbreviated as OLEDs. Today, after 65 years of Silicon-based electronics, organic materials have become viable candidates for applications such as OLEDs in flat panel displays, solar cells, organic lasers, rechargeable batteries and host of other applications in electronics.

Key Words: Organic, polymers, Light Emitting Diode

Introduction

In 1862, Henry Letheby synthesized a dark green coloured powder by anodic oxidation of aniline in sulphuric acid[1]. It was called aniline black. Letheby noted that the powder was mildly conducting. Between 1907 and 1911, Richard Willstater (Nobel Laureate, 1915) characterized oxidation products of Aniline and noted that it is electrochromic. The oxidized form is blue while the reduced form is colourless. This electrochromic behavior under aqueous conditions is important for technological importance.

Small molecules (polycyclic aromatic compounds) and Charge-transfer complexes.

But the fact that organics popularly called Plastics, could carry current started gaining currency in 1950s. Researchers at Bell Labs found that polycyclic compounds such as Perylene, Anthracene and Rubrene under suitable doping conditions exhibited conductivity as high as 1 S cm-1[2,3]. The dopants used were halogens. A prominent example of this is the Perylene-Iodine complex. Such complexes were called the charge-transfer complexes where the organic molecule is electron-donor while the halogen is electron acceptor.These charge-transfer complexes are not purely organic. The first purely organic charge-transfer complex was discovered in 1973 and was called TTF-TCNQ(TTF= tetrathiafulvalene, TCNQ=tetracyanoquinodimethane)[4]. Its electrical conductivity was almost metal-like. TTF-TCNQ initiated a generation of purely organic semiconductors. Superconductivity in purely organic molecule was first discovered in these complexes[5]. The complex Tetramethyl-tetraselenafulvalene-phosphorus hexafluoride ($TMTSF_2PF_6$), a semi-conductor at ambient conditions, shows superconductivity at 0.9 K and 12 K bar. Unfortunately, critical current

densities in these complexes are very small. Alq_3 (tris-quinolatoaluminium) is another prominent example of organic semiconductor. It is used as efficient electron-transporting layer and also emits in the green[6].

Conducting Polymers

An important class in Organic semiconductors is conducting polymers. Polyaniline belongs to this category. Today polyaniline in form of various composites with various materials such as graphene, nanoTiO_2, CNTs is used in supercapacitors. In 1963, another conducting polymer Polypyrrole with very low resistivities was reported by Australians B.A. Bolto, D.E. Weiss and coworkers[7]. Despite these reports, the polymer that actually launched this field of research was Polyacetylene. This polymer was synthesized way back in 1966 by K. Ziegler and G. Natta by polymerizing acetylene using Ziegler-Natta catalyst. A major breakthrough came in 1977 when Shirakawa, MacDiarmid and Heeger synthesized Iodine-doped polyacetylene that exhibited a conductivity of 103 S m-1- a conductivity comparable to that of metals[8].The seminal paper received for publication on May16, 1977, had the title: Synthesis of electrically conducting organic polymers: Halogen derivatives of polyacetylene $(CH)_x$. They were awarded the 2000 Chemistry Nobel for this discovery – for demonstrating that organic material can show conductivity comparable to that of metals. Since then science of conductive polymers has rapidly advanced in various directions. Other polymers studied extensively since 1980s include Polypyrrole, Polyphenylenevinylene and Polyaniline. Polyacetylene may have opened up the field of "Plastic Electronics" but it has not found any practical applications mainly because it is susceptible to oxidation and sensitive to humidity.

Electroluminesence: Organic Light Emitting Diodes.

In early 1950s Andre Bernanose at Nancy Universite, France was first to discover EL in organic molecule-acridine orange[9]. In 1960 Pope and coworkers studied direct current Electroluminesence (EL) in pure single crystal of anthracene although photoconductivity in anthracene was reported as early as 1906[10]. Through the 1950s and 1960s considerable amount of research was devoted to understanding the charge transport properties in these small molecules organic semiconductors.EL from polymer films was first observed by Roger Patridge at National Physical Laboratory at UK[11]. The device consisted of poly (n-vinylcarbazole). The result was patented in 1975 and published in 1983. In 1987, the first organic diode device was produced at Eastman Kodak by Twang and Slyke, setting the stage for present day design of Light Emitting diodes based on organic materials, abbreviated as OLEDs. In 1990, Burroughs et al at the Cavendish Laboratory reported high efficiency green light –emitting polymer based devise using PPV[12].

Applications

The commercial applications of conducting polymers is given below:

Doped polyaniline is used as a conductor and for electromagnetic shielding of electronic circuits. Polyaniline is also manufactured as a corrosion inhibitor.

Poly(ethylenedioxythiophene) (PEDOT) doped with polystyrenesulfonic acid is manufactured as an antistatic coating material to prevent electrical discharge exposure on photographic emulsions and also serves as a hole injecting electrode material in polymer light-emitting devices.

Poly(phenylenevinylidene) derivatives have been major candidates for the active layer in pilot production of electroluminescent displays (mobile telephone displays).

Poly(dialkylfluorene) derivatives are used as the emissive layer in full-colour video matrix displays.

Poly(thiophene) derivatives are promising for field-effect transistors: They may possibly find a use in supermarket checkouts.

Poly(pyrrole) has been tested as microwave-absorbing "stealth" (radar-invisible) screen coatings and also as the active thin layer of various sensing devices.

Other possible applications of conductive polymers include supercapacitors and electrolytic-type capacitors. Their electrochromic properties of polyaniline can be used to produce, *e.g.* "smart

windows" that absorb sunlight in summer. An advantage over liquid crystals is that polymers can be fabricated in large sheets and unlimited visual angles.

Why Organics?

Conductive polymers are lighter, more flexible, and less expensive than inorganic conductors. They can be synthesized at temperatures much lower than what are required for Silicon processin. The availability of raw materials is practically unlimited. Organic semiconductors can be mass-produced at a low cost. It is even possible to produce coatings with ink-jet printers using electronic ink or with classic printing methods. It is possible to print transistors, LEDs, solar cells, sensors, batteries and displays. Another option is to integrate barely visible electronic circuits into fabrics and wallpapers.

Since very thin layers (below 1µm) of material only are needed, the electrical components are inherently flexible and bendable, just like a plastic foil. Additionally, organic materials are soft rather than porous, which means that they can be bent without breaking. This advantage can be utilized when e.g. printing an organic solar cell onto a plastic foil so that it can be rolled up as needed. This is particularly advantageous in production and processing of such components, e.g. they can be transported on rolls rather than large, easily breakable glass surfaces and installed on curved surfaces.

While the advantages are numerous, the disadvantages are few but seriously limit their use in practical applications. In general organic materials have a higher resistance and low carrier mobility and therefore conduct electricity poorly and inefficiently, as compared to inorganic conductors. There is also too little detailed evidence on long-term durability – raising questions on its electronic and optical stability.

Conclusion

Understanding History of scientific concepts and devices can actually help put things in their proper perspective. History also reveals interesting facts: Einstein predicted laser almost 50 years before it was discovered. The phenomenon of Superconductivity and discovery of X-rays was a matter of serendipity. Marie Curie's work on radioactivity was an example of how the human qualities of patience, hardwork and ingenuity were pushed to the limits. Maxwell's equations of electromagnetic radiation were the greatest discovery of 19^{th} century. They already conformed to relativity which was put forward by Einstein a few years later. Michael Faradays'discovery that magnetism can make electricity and vice versa opened up a world of transformers and generators. Faraday was the first scientist to prepare a nanosolution of gold and introduce us to the realm of nanochemistry.

Conductivity in organic materials was demonstrated several times before polyacetylene was synthesized in Shirakawa's lab. But the fact that polyacetylene can show conductivity on par with metals was path-breaking. The previous paragraphs show some of the applications of these polymers. Some of the serious challenges faced by the organic materials are discussed. If and when these challenges are met, low-cost alternatives to silicon-electronics will be the mainstay of our technological existence.

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A Study of Problems Faced by Customers While Using ATMs and Internet Banking Products in Public Sector V/S Private Sector Banks in Thane Region

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Abstract:
Internet banking is regarded as a delivery channel, which over a period of time has gained recognition. It in fact has experienced growth in many countries and has changed the traditional way of banking. This channel has provided competitive advantage to the banks. With the help of internet banking the consumer has an access to number of services just at the click of a mouse.In Today's scenario, role of internet banking is very valuable. Without internet banking no banks can work. In this we analysis, how much internet banking is used in Public and Private sectors bank. Objective of the study is to find the customer satisfaction in respect of internet banking in Public and Private sectors banks. The method of the study is Primary and Secondary both.ATM is the most acknowledged than any other e-channels. The Indian ATM industry has seen explosive growth in recent times. The present study has made an attempt to find out the perception of customers regarding various issues related to ATM/Debit cards. The study concludes that ATM is very convenient mode of electronic banking.
Keywords: Internet Banking, ATM's, Public Sector Banks, Private Sector Banks.

1. Introduction-

The banking industry is expected to be a leading player in e-business. While the banks in developed countries are working primarily via internet as non-branch banks, banks in the developing countries use the Internet as an information delivery tool to improve relationship with customers. Banks have traditionally been in the forefront for utilizing technology to improve their services and efficiency. They have, over a longer period of time, been using electronic and telecommunication networks for delivering a wide range of value added products and services. The delivery channels of banks include direct dial – up connections, private and public networks etc. and the devices include telephone, personal computers including ATMs etc.

In a nut shell, Electronic banking (E-banking) is a generic term encompassing internet banking, mobile banking etc. In other words, it is a process of delivery of banking services and products through electronic channels such as telephone, internet, cell phone etc. The concept and scope of e-banking is still evolving.

The Indian E-Banking Scenario:

In 2001, the Reserve Bank of India survey revealed that of 46 major banks operating

in India, around 50% were either offering e-banking services at various levels or planned to in the near future.According to a research report, while in 2001, India's Internet user base was an estimated 9 lakh; it was expected to reach 90 lakh by 2003. Also while only 1 percent of these Internet users utilized the e-banking services in 1998, the e-banking user base increased to 16.7 percent by mid – 2000.

2. Objectives-

1) To study the e-banking services provided by the public and private banks.

2) To identify the problems faced by customers in accessing e-banking services w.r.t. ATMs and Internet banking.

3. Hypothesis-

H0: There is no significant difference between the average scores for each of the problems related to internet banking, ATMs with respect to type of bank as private and public.

H1: There is significant difference between the average scores for each of the problems related to internet banking, ATMs with respect to type of bank as private and public.

4. Review of literature-

A. **Mittal R. K. and Dhingra Sanjay**(2006-07), in their article "**Technology in Banking Sector: Issues and Challenges**", discussed the issue that the transaction through technology channels cost much less to the banks than the customers reaching the bank and doing the transactions. In the last decade banks have invested heavily in the technology. In the use of information technology, the new private and foreign sector banks have taken lead over the public and old private sector banks. Today public sector banks are also investing heavily in technology to compete with the new private and foreign sector banks. In the study authors have identified the different technology issues and challenges such as choice of right channel, justification of IT investment in terms of ROI (Rate of Interest), e-governance, customer relationship management, security concerns, penetration of IT in rural areas etc. Banks are required to address these issues and challenges effectively to stay in business and grow.

B. **Agarwal R., Rastogi S., Mehrotra A.,** (2009), in their article "**Customers perspectives regarding e-banking in an emerging economy**" determined factors affecting customer perception and attitude towards and satisfactionwith e-banking is an essential part of a bank's strategy formulation process in anemerging economy like India. To gain this understanding in respect of Indian customers,the study was conducted on respondents taken from the northern part of India. The majorfindings depict that customers are influenced in their usage of e-banking services by thekind of account they hold, their age and profession, attach highest degree of usefulness tobalance enquiry service among e-banking services, consider security & trust mostimportant in affecting their satisfaction level and find slow transaction speed the mostfrequently faced problem while using e-banking.

C. **Sudhakar A. M., Suryanarayana**, (2011),in their article "**Emerging mobile banking scenario and its adoption in India: a study**", explained that with broadband communication technological developments and mobile phonespenetration(481 million by June 2009) into common man's life have triggered majorthrust in the Banking service sector of India. With Mobile Banking- a revolutionaryapproach to banking transactions has created a strong connectivity between customersand the banks as both will transact with minimum cost and in minimum time. It is atimely and its cost effective services can deliver mobile money to non-banked poorpeople and will induce economic growth of the country. This article discusses the statusof Mobile Banking in India and other countries with emphasis on data security andstandards and its implication on banking sector.

D. **Rimpi Kaur** (2013),in her article "**The impact of electronic banking on banking transactions: A cost-benefit**" explained that banks are shifting focus from paper-based to electronic transactions. This paper analyses the computerization, expenditure on electronic banking and cost-benefit analysis of paper-based and electronic transactions. There is a swing from paper-based transactions to electronic transactions, with electronic transactions escalating drastically and earning business value at a triple rate. Per transaction value is 168 times per transaction cost which shows sound returns. The paper evaluates the effect of transactions on cost and value through correlation-coefficient and concludes that electronic banking has significant impact on the cost and value of each transaction.

5. Research Methodology-

In order to understand the problems faced by the customers while using ATMs and Internet banking services, the researcher has used Thane region. Researcher has studied 3 public sector banks and 3 private sector banks for the study. The researcher has chosen State bank of India, Bank of India and Bank of Baroda in public sector for the present study. ICICI bank. Axis Bank and HDFC bank are chosen by the researcher in a group of private sector banks. The sample taken by the researcher is 556 customer respondents. The data is collected through convenience sampling method with the help of pre-structured and pre-coded questionnaire method of data collection.

6. Analysis and Interpretation of Data-

TABLE 1: PROBLEMS RELATED TO ATM

MEAN RANK TABLE

	BANK	N	Mean Rank	Sum of Ranks
PTUA1	Nationalised Bank	273	271.87	74220.00
	Private Bank	283	284.90	80626.00
	Total	556		
PTUA2	Nationalised Bank	273	283.74	77460.00
	Private Bank	283	273.45	77386.00
	Total	556		
PTUA3	Nationalised Bank	273	281.48	76844.50
	Private Bank	283	275.62	78001.50
	Total	556		
PTUA4	Nationalised Bank	273	281.18	76763.50
	Private Bank	283	275.91	78082.50
	Total	556		
PTUA5	Nationalised Bank	273	279.92	76419.50
	Private Bank	283	277.13	78426.50
	Total	556		
PTUA6	Nationalised Bank	273	274.14	74839.50
	Private Bank	283	282.71	80006.50
	Total	556		

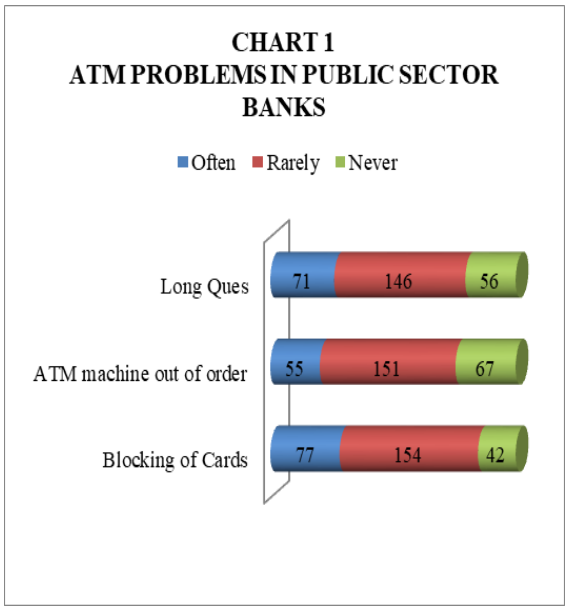
Source: By Researcher

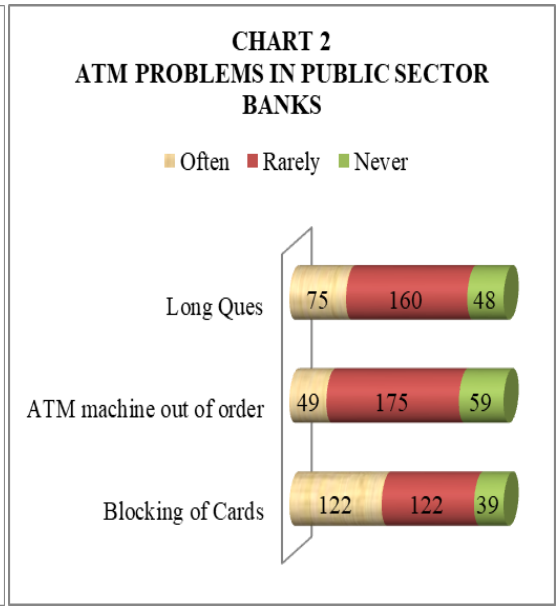
Mann-Whitney U test result:

	PTUA1	PTUA2	PTUA3	PTUA4	PTUA5	PTUA6
Mann-Whitney U	36819.000	37200.000	37815.500	37896.500	38240.500	37438.500
Wilcoxon W	74220.000	77386.000	78001.500	78082.500	78426.500	74839.500
Z	-1.057	-.858	-.469	-.438	-.228	-.698
p-value	.291	.391	.639	.661	.819	.485

TABLE 2: ATM PROBLEMS

	PUBLIC			**PRIVATE**		
	Often	Rarely	Never	Often	Rarely	Never
Blocking of Cards	77	154	42	122	122	39
ATM machine out of order	55	151	67	49	175	59
Long Queue	71	146	56	75	160	48





Here, the public sector banks do face lots of ATM related problems as compared to private sector banks in the selected area for the research. The problems are that ATM machines are not working at point of sale.

TABLE 3: INTERNET BANKING PROBLEMS

MEAN RANK TABLE

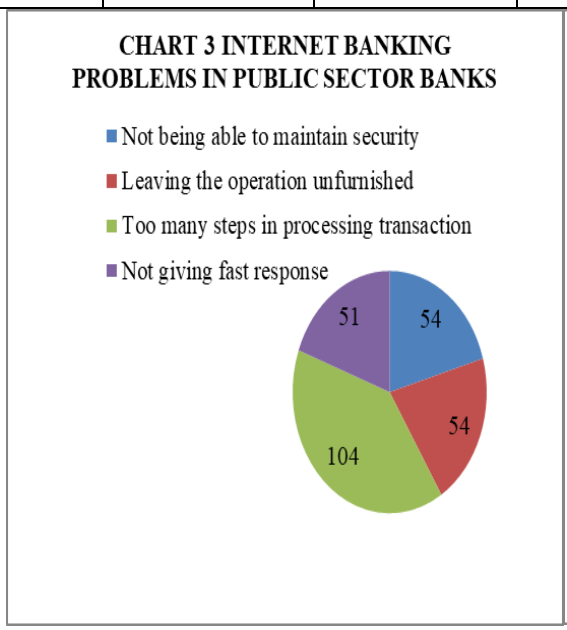
	BANK	N	Mean Rank	Sum of Ranks
PTUB1	Nationalised Bank	273	267.85	73123.00
	Private Bank	283	288.77	81723.00
	Total	556		
PTUB2	Nationalised Bank	273	290.11	79200.00
	Private Bank	283	267.30	75646.00
	Total	556		
PTUB3	Nationalised Bank	273	280.58	76598.00
	Private Bank	283	276.49	78248.00
	Total	556		
PTUB4	Nationalised Bank	273	285.55	77955.50
	Private Bank	283	271.70	76890.50
	Total	556		
PTUB5	Nationalised Bank	273	279.08	76189.00
	Private Bank	283	277.94	78657.00
	Total	556		
PTUB6	Nationalised Bank	273	296.61	80974.50
	Private Bank	283	261.03	73871.50
	Total	556		
PTUB7	Nationalised Bank	273	285.40	77915.00
	Private Bank	283	271.84	76931.00
	Total	556		

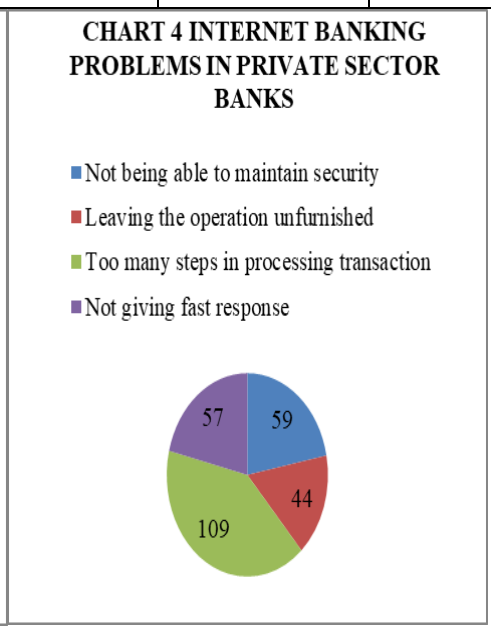
Source: By Researcher

Mann-Whitney U test result:

	PTUB1	PTUB2	PTUB3	PTUB4	PTUB5	PTUB6	PTUB7
Mann-Whitney U	35722.000	35460.000	38062.000	36704.500	38471.000	33685.500	36745.000
Wilcoxon W	73123.000	75646.000	78248.000	76890.500	78657.000	73871.500	76931.000
Z	-1.779	-1.878	-.337	-1.142	-.093	-2.939	-1.079
p-value	.075	.060	.736	.254	.926	.003	.281

TABLE 4: INTERNET PROBLEMS					
PUBLIC			PRIVATE		
Often	Rarely	Never	Often	Rarely	Never
54	156	63	59	161	63
54	145	74	44	172	67
104	122	47	109	125	49
51	147	65	57	174	56





Respondent finds more problems with private sector banks than that of public sector banks for this particular problem.

7. Findings and conclusion-

- Here, the public sector banks do face lots of ATM related problems as compared to private sector banks in the selected area for the research.
- The problems are that ATM machines are not working at point of sale. There is also less availability of POS terminals.
- In case of internet banking transactions private sector bank customers face lots of problems like security aspects while handling transactions, no fast response as public sector banks do give.
- Also people do face problem of too many steps in processing of transactions while handling internet banking services.
- The proportion of facing internet problems due to insufficient information provided by banks is more in SBI. The ICICI keep on updating and providing information to the customers which helps them to solve internet problems.
- It has been found that even after taking care of internet problems by all banks they fails to maintain the security of internet banking.

- As per customer survey in BOI& ICICI the proportion of not being able to maintain security is more as compared to others.

8. Suggestions-

- ❖ Banks should reduce the formalities while operating internet banking transactions.
- ❖ Banking activities must be inculcated right from school studies. The basic knowledge of e-banking transactions should be given to the student so that they can go well with this modern banking.
- ❖ In an e-banking, especially net banking, Banks are not offering online income tax returns system. Banks must start or include this facility to get more and more database.
- ❖ Customer should take at most care that they should not disclose their personal details over phone or by e-mail as banks never asks for this.

9. Scope for further research-

Here, the researcher will try to find out what effective measures have been taken by the public sectors and private sectors in order to solve the problems and satisfy the customers.

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A Study of Green Banking as Innovative Ethical Banking WRT State Bank of India

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Abstract:

Change is the need of hour to for survival in all spheres .The world has seen much focus on economic progress and mankind has made giant steps in its journey through time. The side effects of the development process have, however, also been equally enormous loss of biodiversity, climatic change, environmental damage, etc. Bank is also not the exception for this. This paper tries to find out the ways to Go Green through 'Green Banking'. Generally, the banks are using 1. Online banking instead of branch banking. 2. Paying bills online instead of mailing them. 3. Opening up accounts at online banks, instead of large multi-branch banks 4. Finding the local bank in your area that is taking the biggest steps to support local green initiatives. The researcher will collect the data on green banking through interview and questionnaire w.r.t. State Bank of India.

Key Words: CEO, Green Banking, Green House Effect Online - Banking, RBI, Global Warming.

Introduction:

Environmentalism is a broad philosophy and social movement regarding concerns for environmental conservation and improvement of the state of the environment. Environmentalism and environmental concerns are often represented by the color 'green'. Global warming, also called as "Green House Effect" is a global issue that calls for a global response. The warming effect of certain man-made gas emission such as carbon-dioxide, methane, nitrous oxide and hydro-fluro carbon is found responsible for distortion in climate changes. The rapid change in climate will probably be too great to allow many eco systems to suitably adapt, since the changes have direct impact on bio diversity, agriculture, forestry, dry land, water resources and human health. However, there is general lack of adequate awareness on the above issues and hence there is urgent need to promote certain urgent measures for sustainable development and corporate social responsibility.

"The supreme reality of our time is… the vulnerability of our Planet."
- John F. Kennedy

To avoid falling into similar trap, the impulse of 'going green' is running faster than blood in Indian Incorporations veins. From IT giants to luxurious hotels, from Automobiles to Aviations, from Mutual Funds to Banks corporate India is moving fanatically ahead with green initiatives.

As a responsible financial organization of the country with its crucial role in financing the economic and developmental activities of the country, banks have to play in addressing the above issues, both in terms of its obligations and opportunities by virtue as a responsible corporate citizen and as a financier.

Definition:

Green Banking is like a normal bank, which considers all the social and environmental factors; it is also called as an ethical bank. Ethical banks have started with the aim of protecting the environment. These banks are like a normal bank which aims to protect the environment and it is controlled by same authorities as what a traditional bank do. Green banking is like a normal bank, which considers all the social and environmental/ecological factors with an aim to protect the environment and conserve natural resources. It is also called as an ethical bank or a sustainable bank. They are controlled by the same authorities but with an additional agenda toward taking care of the Earth's environment/habitats/resources. For banking professionals green banking involves the tenets of sustainability, ethical lending, conservation and energy efficiency.

There are many differences compared with normal banking, Green Banks give more weight to environmental factors, their aim is to provide good environmental and social business practice, they check all the factors before lending a loan, whether the project is environmental friendly and has any implications in the future, you will awarded a loan only when you follow all the environmental safety standards.

Defining green banking is relatively easy. Green Banking means promoting environmental – friendly practices and reducing your carbon footprint from your banking activities. This comes in many forms

1. Using online banking instead of branch banking.
2. Paying bills online instead of mailing them.
3. Opening up accounts at online banks, instead of large multi-branch banks
4. Finding the local bank in your area that is taking the biggest steps to support local green initiatives.

Green banking can benefit the environment either by reducing the carbon footprint of consumers or banks. Either a bank or a consumer can conserve paper and benefit the environment. Ideally, a green banking initiative will involve both. Online banking is an example of this. When a bank's customer goes online, the environmental benefits work both ways. Green banking means combining operational improvements and technology, and changing client habits.

Objectives of the Study:

1) To study concept of 'Green Bank'
2) To identify the steps necessary to adopt Green Banking
3) To check the awareness of green banking among bank employees, associates and general public**.**
4) To create awareness about green banking among the general public and consumers and bank employees**.**
5) To reduce CO2 emissions from electricity consumption and transportation, increase recycling (paper, toners, cartridges and batteries), increase the use of green products by bank branches.

Research Methodology:

The research methodology used in this study is based on primary as well as secondary data. The primary data was collected from the study conducted through telephonic interactions and personal interviews. The study examines major aspects concerned with the Green Banking. Specially structured questionnaires and interviews with employees, of well established banks and general public have been used for survey purpose.

RESEARCH UNIVERSE : STATE BANK OF INDIA (THANE BRANCHES) SAMPLE SIZE: 12 BANK MANAGERS AND 50 BANK EMPLOYEES. SAMPLING METHOD : CONVENIENCE SAMPLING METHOD OF SAMPLE COLLECTION: INTERVIEW

Steps in Green Banking:

From the empirical study, it is found that following are some of the steps that can be taken for going green in banking:

1. **Go Online:-** Online banking is the developing concept in young and corporate India. Online banking helps in additional conservation of energy and natural resources. Online Banking includes: a. Paying bills online, b. Remote deposit, c. Online fund transfers and d. Online statements. It creates savings from less paper, less energy, and less expenditure of natural resources from banking activities. Customers can save money be avoiding late payments of fees and save time by avoiding standing to queues and paying the bill from home online.
2. **Use Green Checking Accounts:-** Customers can check their accounts on ATM or special touch screens in the banks. This can be called as green checking of account. Using a green checking account helps the environment by utilizing more online banking services including online bill payment, debit cards, and online statements. Banks should promote green checking by giving some incentives to customers by giving higher rate of interests, waiver or discount in fees etc.
3. **Use Green Loans for Home Improvements:-** The Ministry of Non-renewable Resource in association with some nationalized and scheduled banks undertook an initiative to go green by paying low interest loans to the customers who would like to buy solar equipments. The rate of interest is as low as 4% p.a. Before you undertake a major home improvement project, study if the project can be done in an eco-friendly manner and if you might qualify for a green loan from a bank Green loan are perfect for energy-saving project around the house.

   The new Green Home Loan Scheme from SBI, for instance, will support environmentally friendly residential projects and offer various concessions. These loans will be sanctioned for projects rated by the Indian Green Building Council (IGBC) and offer several financial benefits –a 5 percent concession in margin, 0.25 percent concession in interest rate and processing fee waiver.
4. **Power Savings Equipments:-** Banks can directly contribute to controlling climate change and as an initial step they intend to start a campaign to replace all fused GSL bulbs, in all owned premises offices and residential. Banks can also make a feasibility study to make rain water harvesting mandatory in all the Bank's owned premises. In December 2009 Indusind Bank inaugurated Mumbai's first solar-powered ATM as part of its 'Green Office Project' campaign titled 'Hum aur Hariyali'.
5. **Use Green Credit Cards:-** Some of the banks introduced Green Credit Card. The

benefit of using a green credit card is that banks will donate funds to an environment-friendly non-profit organization from every rupee you spend on your credit card to a worthwhile cause of environment protection.

6. **Save Paper:-** Bank should purchase recycled paper products with the highest post-consumer waste content possible. This includes monthly statements, brochures, ATM receipts, annual reports, newsletters, copy paper, envelopes etc. Whenever available, vegetable-based inks are used instead of less environmentally friendly oil-based inks.
7. **Use of Solar and Wind Energy:-** Using solar and wind energy is one of the noble cause for going green. State Bank of India (SBI) has become the first bank in the country to venture into generation of green power by installing windmills for captive use. As part of its green banking initiative, SBI has installed 10 windmills with an aggregate capacity of 15 MW in the states of Tamil Nadu, Maharashtra and Gujarat.
8. **Mobile Banking:-** Mobile banking is tricky. On the one hand, it is great to have the ability to check balances, transfer funds or pay bills from you phone. One the other hand, it saves time and energy of the customers. It also helps in reducing use of energy and paper of the bank. Most of the Indian banks introduced this paper-less facility.

Findings:

1. Basically Green banking avoids as much paper work as possible and rely on online/ electronic transactions for processing so that we get green credit cards and green mortgages. Less paperwork means less cutting of trees. It also involves creating awareness to banking business people about environmental and social responsibility enabling them to do an environmental friendly business practice.
2. Green Ethical banks adopt and implement environmental standards for lending, which is really a proactive idea that would enable eco-friendly business practices which would benefit our future generations.
3. When we are awarded with a loan, the interest of that loan is comparatively less with normal banks because green banks give more importance to environmental friendly factors - ecological gains.
4. Natural resources conservation is also one of the underlying principles in a green bank while assessing capital/operating loans to extracting/industrial business sector.
5. Green Banking as a concept is a proactive and smart way of thinking with a vision for future sustainability of our only Spaceship Earth - as design science explorer Richard Buckminster Fuller called our Earth.
6. The value proposition for corporations to go green includes many of the same issues as that for individual consumers but on a much large scope and with additional concerns. Corporations may share a desire to reduce carbon footprint and enhance security by eliminating paper waste, but they are also extremely concerned with eliminating or decreasing errors due to manual processing and with creating a profitable bottom line. For these reasons and more, corporations are actively pursuing green programs, many companies are taking active steps to reduce waste, implement sustainability measures and increase profitability by going green.

Conclusion:

Banks are responsible corporate citizens. Banks believe that every small 'GREEN' step taken today would go a long way in building a greener future and that each one of them can work towards to better global environment. 'Go Green' is an organization wide initiative that moving banks, their processes and their customers to cost efficient automated channels to

build awareness and consciousness of environment, nation and society Green Banking can give following benefits.

1. Basically Ethical banking avoids as much as paper work, you get go green credit cards, go green mortgages and also all the transactions done through online Banking.
2. Creating awareness to business people about environmental and social responsibility enabling them to do an environmental friendly business practice.
3. They follow environmental standards for lending, which is really a good idea and it will make business owners to change their business to environmental friendly which is good for our future generations.

Overall Green banking is really a good way for people to get more awareness about global warming; each businessman will contribute a lot to the environment and make this earth a better place to live. Thanks to green banking. Until a few years ago, most traditional banks did not practice green banking or actively seek investment opportunities in environmentally-friendly sectors or businesses. Only recently have these strategies become more prevalent, not only among smaller alternative and cooperative banks, but also among diversified financial service providers, asset management firms and insurance companies. Although these companies may differ with regard to their stated motivations for increasing green products and services (e.g. to enhance long-term growth prospects, or sustainability principles on which a firm is based), the growth, variation and innovation behind such developments indicate that we are in the midst of a promising drive towards integrating green financial products into mainstream banking.

This concept of "Green Banking" will be mutually beneficial to the banks, industries and the economy. Not only "Green Banking" will ensure the greening of the industries but it will also facilitate in improving the asset quality of the banks in future.

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Analysis of Customer's Opinion about Mobile Banking WRT Mumbai Region

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Abstract:
Mobile Banking (MB) means a financial transaction conducted by logging on to a bank's website using a cell phone, such as viewing account balances, making transfers between accounts, or paying bills. It is a term used for performing balance checks, account transactions, payments etc. via a mobile device such as a mobile phone. Here, the researcher has carried out a survey of 250 customers on a random sampling method. The questionnaire is divided into five aspects. They are
1. Customer's opinion about usefulness of the MB
2. Customer's opinion about use of the MB
3. Customer's trust on their bank while using MB
4. Customer's opinion about security provided by the bank for MB users
5. Precautions taken by the customers while using MB.

It will be analysed through standard deviation, percentage and graphical representation.

Key Words: Mobile Banking, Customer's Opinion, Standard Deviation

Introduction:
Mobile Banking (MB) means a financial transaction conducted by logging on to a bank's website using a cell phone, such as viewing account balances, making transfers between accounts, or paying bills. It is a term used for performing balance checks, account transactions, payments etc. via a mobile device such as a mobile phone. In recent time Mobile banking is most often performed via SMS or the Mobile Internet but can also use special programs called clients downloaded to the mobile device.

In general term we can categorized the mobile banking below –
* Mobile Accounting
* Mobile Brokerage
* Mobile Financial Information Services

Objectives of the Study

14.1 To study the opinion of the customer about mobile banking.

Scope of the Study
This study is conducted to find out the correlation between
19.1 Age and MB
19.2 Gender and MB
19.3 Qualification and MB
19.4 Socio economic status and MB

Review of Literature

1. Sudhakar A. M., Suryanarayana, (2011), "Emerging mobile banking scenario and its adoption in India: a study", With broadband communication technological developments and mobile phones penetration(481 million by June 2009) into common man's life have triggered major thrust in the Banking service sector of India. With Mobile Banking- a revolutionary approach to banking transactions has created a strong connectivity between customers and the banks as both will transact with minimum cost and in minimum time. It is a timely and its cost effective services can deliver mobile money to non-banked poor people and will induce economic growth of the country. This article discusses the status of Mobile Banking in India and other countries with emphasis on data security and standards and its implication on banking sector.
2. Datta S. K. (2010), "Acceptance of E-banking among Adult Customers: An Empirical Investigation in India", revealed that Internet banking is a form of self service technology. The finding depicts many factors like security & privacy, trust, innovativeness, familiarity, awareness level increase the acceptance of e-banking services among Indian customers. The finding shows that in spite of their security and privacy concern, adult customers are willing to adopt online banking if banks provide him necessary guidance. Based on the results of current study, Bank's managers would segment the market on the basis of age group and take their opinion and will provide them necessary guidance regarding use of online banking.
3. Laukknen T., Lauronen J. (2005), "Consumer value creation in mobile banking services" The paper presents findings of the study that explored consumer value creation in various mobile banking services. New electronic channels are replacing the more traditional ones. Mobile devices represent the recent development in electronic service distribution. An exploratory study was conducted on experienced electronic banking customers by using a qualitative in-depth interviewing method. The findings increase the understanding of customer-perceived value and value creation on the basis of attributes of mobile services and customer-perceived disadvantages of mobile phones in electronic banking context. The findings allow practitioners to improve their services and marketing strategies and pass on information to the academics about interesting future research areas.
4. Suoranta M., Mattila M. (2004), "Mobile banking and consumer behaviour: New insights into the diffusion pattern", provided an indication of the characteristics of potential subsequent adopters of mobile banking, and of differences between user segments. Consequently, the authors are able to comment on the influence of certain demographic characteristics and the preferred communication mode of customers on the adoption and future usage of mobile banking services. The quantitative survey that sheds more light on this researched issue employed a traditional method of postal questionnaire. The data were collected in Finland during May–July 2002 and include 1,253 survey responses.
5. Sarel D., Howard M. (2003), "Marketing online banking services: The voice of the customer", revealed significant differences in attitudes and opinions between early users and those that banks hope will adopt next. Most importantly, future prospects could be characterised as indifferent about online banking; many were not convinced about its benefits and the value it provides. While the potential to expand the market for online banking services exists, banks need to re-examine their marketing approach.

Research Design for the Present Study

In this study the researcher compared the views of the customers about and mobile banking with reference to age, gender, education and socio economic status. The correlation between age, gender, socio economic status and education mobile banking were seen. Thus this study is descriptive, quantitative and qualitative research. The researcher used the questionnaire to collect data. The sample was collected from 250 customers of different banks residing in Mumbai, using online and mobile banking and was easily available.

Analysis and Interpretation OD Data

The opinions of the customers were classified into five aspects as mentioned below:

- ✓ Customer's opinion about usefulness of the MB
- ✓ Customer's opinion about use of the MB
- ✓ Customer's trust on their bank while using MB
- ✓ Customer's opinion about security provided by the bank for MB users
- ✓ Precautions taken by the customers while using MB

1. **Customer's opinion about usefulness of the MB**

In questionnaire seven questions were related to customer's opinion about usefulness of mobile banking. The maximum score for each question was 4, thus the total maximum score was 28. The following table shows the mean score of the customer's opinion about usefulness of the mobile baking (out of the total score i.e. 28), standard deviation and higher limit, moderate limit and lower limit.

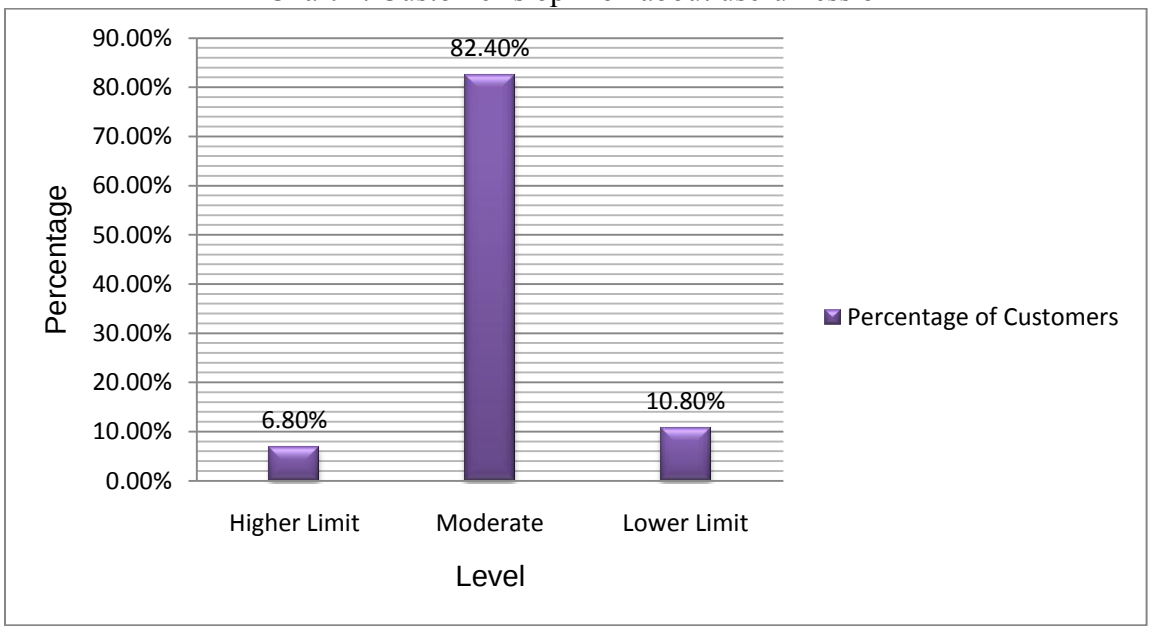
To calculate higher limit, the researcher add 1 standard deviation in mean and to calculate the lower limit 1 standard deviation was deducted from the mean.

Table 1: Customer's opinion about usefulness of MB

	Mean Score (Out of 28)	S.D.	Higher Limit	Moderate	Lower Limit
	18.57	**4.14**	**22.71**	**18.57**	**14.43**
No. of Customer	**250**		**17**	**206**	**27**
Percentage of Customers	**100 %**		**6.8 %**	**82.4 %**	**10.8 %**

The above table shows that the mean score of the customer's opinion about usefulness of the mobile banking was 18.57. The standard deviation was 4.14. 6.8% customers believed that mobile banking in highly useful for them. 82.4% customers believed that online baking is moderately useful for them. 10.8% customers believed that mobile banking is less useful. Thus, the researcher found that approx. 89% customers believed that mobile banking is useful for them.

Chart 1: Customer's opinion about usefulness of MB



2. Customer's opinion about use of the MB

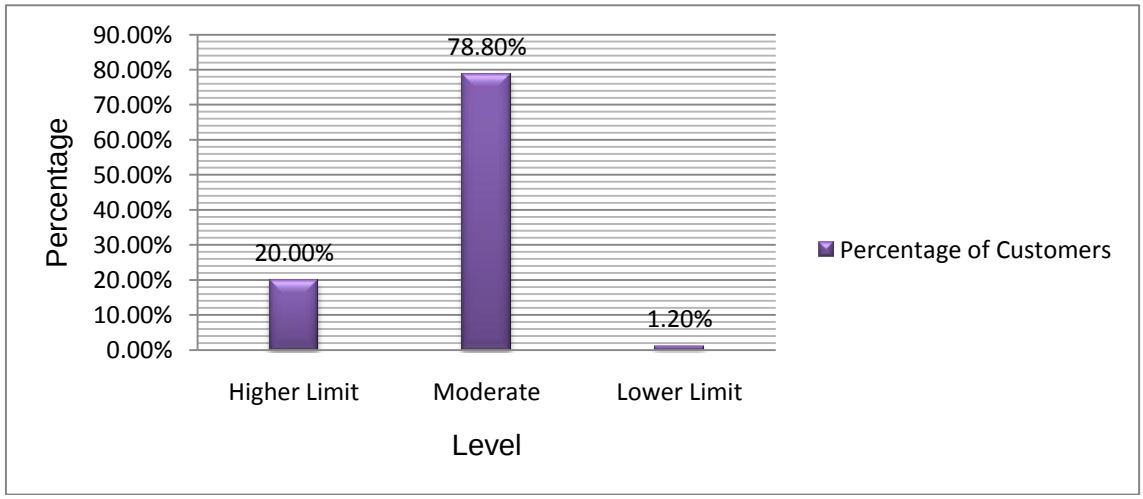
In questionnaire four questions were related to customer's opinion about the using of mobile banking. The maximum score for each question was 4, thus the total maximum score was 16. The following table shows the mean score of the customer's opinion about the using of online baking (out of the total score i.e. 12), standard deviation and higher limit, moderate limit and lower limit.

Table 2: Customer's opinion about the use of MB

	Mean Score (Out of 16)	S.D.	Higher Limit	Moderate	Lower Limit
	8.80	**2.21**	**11.01**	**8.80**	**6.59**
No. of Customer	**250**		**50**	**197**	**3**
Percentage of Customers	**100 %**		**20 %**	**78.8 %**	**1.2 %**

The above table shows that the mean score of the customer's opinion about the using of mobile banking was 8.80. The standard deviation was 2.21. 20% customers believed that mobile banking is very easy to use and they were using it without any worries. 78.8% customers believed that mobile banking is fairly easy to use and they were using it without worries. 1.2% customers believed that mobile banking is not easy to use and they were little worried as there was no personal relation with the bank.

The following is the graphical presentation of the above facts.
Chart 2: Customer's opinion about the use of MB



3. Customer's trust on their bank while using MB

In questionnaire five questions were related to customer's trust on their bank. The maximum score for each question was 4, thus the total maximum score was 28. The following table shows the mean score of the customer's trust on their bank (out of the total score i.e. 20), standard deviation and higher limit, moderate limit and lower limit.

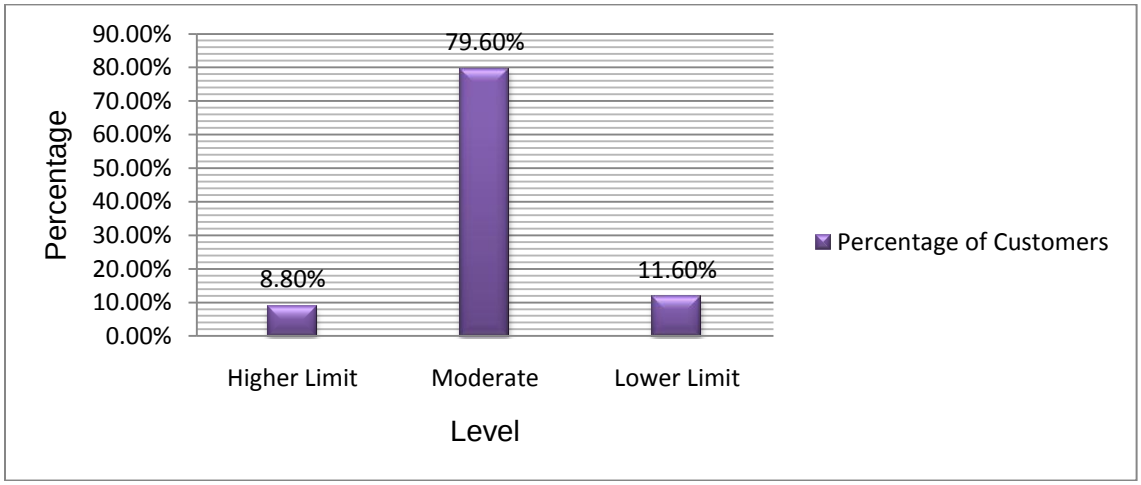
Table 3: Customer's trust on their bank

	Mean Score (Out of 20)	S.D.	Higher Limit	Moderate	Lower Limit
	15.18	**3.89**	**19.07**	**15.18**	**11.29**
No. of Customer	**250**		**22**	**199**	**29**
Percentage of Customers	**100 %**		**8.8 %**	**79.6 %**	**11.6 %**

The above table shows that the mean score of the customer's trust on their bank was 15.18. The standard deviation was 3.89.

8.8% customers were having full trust on their banks while using MB. 79.6% customers were having moderate trust on their banks while using MB. 15.2% customers were having less trust or no trust on their bank while using MB.

Chart 3: Customer's trust on their bank



4. Customer's opinion about security provided by the bank to MB users

In questionnaire three questions were related to customer's opinion about the security provided by the bank. The maximum score for each question was 4, thus the total maximum score was 12. The following table shows the mean score of the customer's opinion about the security provided by the bank (out of the total score i.e. 12), standard deviation and higher limit, moderate limit and lower limit.

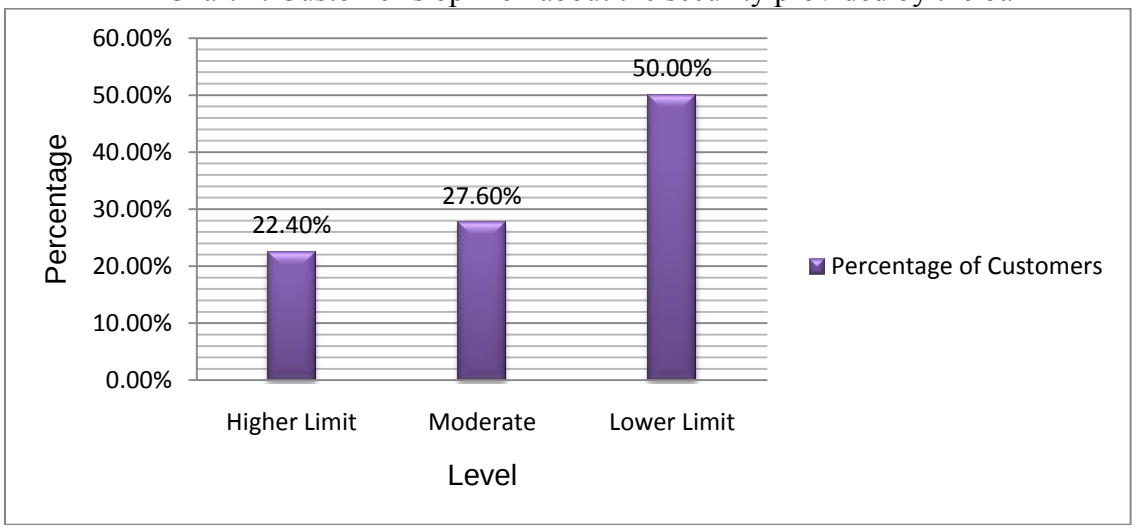
Table 4: Customer's opinion about the security provided by the bank

	Mean Score (Out of 12)	S.D.	Higher Limit	Moderate	Lower Limit
	1.78	**1.24**	**3.01**	**1.78**	**0.54**
No. of Customer	**250**		**56**	**69**	**125**
Percentage of Customers	**100 %**		**22.4 %**	**27.6 %**	**50 %**

The above table shows that the mean score of the customer's opinion about the security provided by the bank was 1.78. The standard deviation was 1.24.

22.4 % customers believed that there are high chances of misuse their accounts if they use MB due to weak security provided by the banks. 27.6% customers believed that there are moderate chances of misuse their accounts if they use MB. 50% customers believed that there is less chance or no chance of misusing their accounts by other persons if they use MB. The study clearly shows that approximately 50% customers were satisfied with the security measures taken by the banks for MB users.

Chart 4: Customer's opinion about the security provided by the bank



5. Precautions taken by the customers

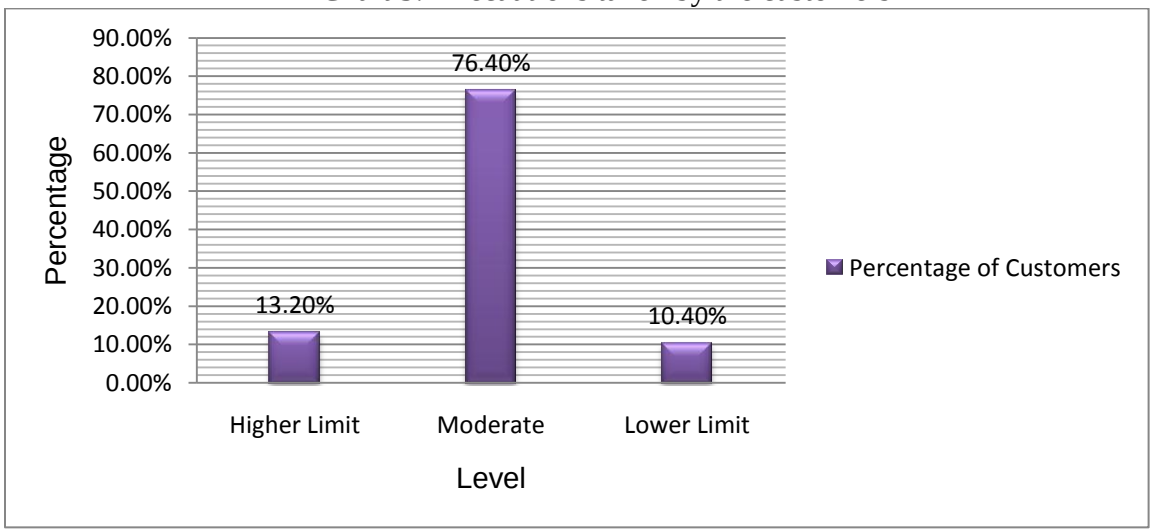
In questionnaire five questions were related to the precautions taken by the customers. The maximum score for each question was 4, thus the total maximum score was 20. The following table shows the mean score of the precautions taken by the customers (out of the total score i.e. 20), standard deviation and higher limit, moderate limit and lower limit.

Table 5: Precautions taken by the customers

	Mean Score (Out of 20)	S.D.	Higher Limit	Moderate	Lower Limit
	11.97	**2.11**	**14.08**	**11.97**	**9.86**
No. of Customer	**250**		**33**	**191**	**26**
Percentage of Customers	**100 %**		**13.2 %**	**76.4 %**	**10.4 %**

The above table shows that the mean score of the precautions taken by the customer was 11.97. The standard deviation was 2.11. 13.2% customers were taken high precautions, 76.4 % customers taken moderate precaution while 10.4% had not taken precautions or were taken less precautions.

Chart 5: Precautions taken by the customers



Findings and Conclusion:

The study showed that approximately 89% customers believed that MB is useful for them. 1.2% customers felt that the use of mobile banking is not very easy while 98.8% customers found it easy to operate mobile banking. 11.2 % customers were highly encouraged by the bank for MB, 20% were highly encouraged by the bank officials while 19.6% were highly encouraged by their friends or colleagues. More than 50% of the customers were highly encouraged by banks, banks officials and friends or colleagues to use MB. 8.4% customers also believed that they were highly discouraged by their friends or colleagues for MB. 78% customers were having more than 75% trusts on their banks. 50% customers were fully satisfied with the security provided by their banks and they were sure that no one is ambled to stolen their money. 89.60% customers took precautionary measures by themselves. The findings of the study show that maximum customers have positive attitude towards mobile banking.

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Effect of Yoga on Muscular Endurance of Slum Area Girls of Mumbai

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Abstract:

The slum-dwelling population of India has raised from 27.9 million in 1981 to 61.8 million in 2001. According to recent estimates, Maharashtra, Uttar Pradesh, Andhra Pradesh and Madhya Pradesh will be having largest share of slum population in India by 2017. It was therefore felt necessary to undertake a research project in the area of health and fitness of slum area students to improve the decline status of health through 'Yoga'. The present experiment was conducted by using ***'non equivalent group design'***. Hundred *(n=100)* girls students, age ranged from 13 to 15 years, from Maharashtra Education Society's ChhatrapatiShivajiVidyalaya, Dharavi, Sion, Mumbai were selected as samples for this study. Yogic Practices were selected as Independent Variable for the experiment whereas,Health Related Physical Fitness Component 'Muscular Endurance' was selected as Dependent Variable. There were two groups for this Experimental Study Viz. Experimental Group and Control Group. Experimental Group (n=50) and one Control Group (n= 50). Experimental group was received training of '***Yogic Practices***' for the period of 12 weeks daily in the morning for one hour except Sundays. Result of the study was seen that the adjusted f-value is 25.66 which is significant at 0.01 level with df=1/97 when pre Bent Knee Sit Ups of Muscular Endurance of slum area school girls was taken as covariant. It shows that adjusted mean scores of Bent Knee Sit Ups Test of Muscular Endurance of slum area school girls of experimental and control groups differs significantly where pre Bent Knee Sit Ups Test of Muscular Endurance of slum area school girls was taken as covariant.Conclusion of this study was, ***'12 Weeks Yoga Training Program'*** is effective to improve Muscular Endurance of slum area school girls.

Introduction:

Slum Population in India simply refers to people living in slum areas below the poverty line. As India is still on the path of development, there is large number of people living below the poverty line.According to census in 2001 **(India Guide, 2015),** the slum-dwelling population of India has raised from 27.9 million in 1981 to 61.8 million in 2001. According to recent estimates, Maharashtra, Uttar Pradesh, Andhra Pradesh and Madhya Pradesh will be having largest share of slum population in India by 2017 (**The Hindu, October 2013)**.

The children residing in the slum area pose a serious threat to their current health and future prospects **(Thomas, 2010)**. As the most fragile members of society, they are most vulnerable to disease and environmental stress; their long-term well-being depends on the sustained ability of the Earth's resources to support this still expanding population.

This indicates that the gravity of health condition of the children living in slum areas. It was therefore felt necessary to undertake a research project in the area of health and fitness of slum area students to improve the decline status of health through 'Yoga'.

Objective of the Study

To compare adjusted mean scores of Muscular Endurance of girls of the experimental group and control group by taking pre Muscular Endurance as covariate.

Hypothesis of the study

H01: There is no significant difference in adjusted mean scores ofMuscularEndurance as measured by Bent Knee Sit Ups test of slum area school girls of experimental and control group by taking pre Muscular Endurance of slum area school girls as covariate

Method

Design of the study

The present experiment was conducted by using ***NON EQUIVALENT GROUP design***

Sample

Hundred ***(n=100)*** girls students, age ranged from 13 to 15 years, from Maharashtra Education Society's ChhatrapatiShivajiVidyalaya, Dharavi, Sion, Mumbai were selected as samples for this study.

Independent Variable

The following Yogic Practices presented in Table 1 were selected as Independent Variable for the experiment.

Table 1

Independent Variablesi.e.Asana, Pranayama and Kriya

Seating Position Asana	**KRIYA**
• Vajrasana	• Kapalabhati
• Padmasana	
• Vakrasana	
• Paschimottanasana	
Prone Position Asana	**Pranayama**
• Bhujangasana	• Anulom-Vilom
• Ardhsalbhasana	• Ujjayi
• Shalbhasana	
• Makrasana	
Supine Position Asana	
• Shavasana	
• Pawanmuktasana	
• Halasana	
• Naukasana	
Standing Position Asana	
• Tadasana	
• Vrikshasana	
• Utkatasana	
• Padhastasana	

Dependent Variable

Health Related Physical Fitness Component '***MUSCULAR ENDURANCE'*** was selected as Dependent Variable.

Procedure of the Study

There were two groups for this Experimental Study Viz. Experimental Group and Control Group with Pretest and Posttest, the selected sample were randomly assigned into two equal groups viz., one Experimental Group (n=50) and one Control Group (n= 50). Experimental group was received training of '***Yogic Practices'*** for the period of 12 weeks daily in the morning for one hour except Sundays.

Result

To compare adjusted mean scores of Muscular endurance of girls of the experimental group and control group by taking pre Muscular Endurance as covariate.Result of the study was seen that the adjusted f-value is 25.66 which is significant at 0.01 level with df=1/97 when pre Bent Knee Sit Ups Test of Muscular Endurance of slum area school girls was taken as covariant. It shows that adjusted mean scores of Bent Knee Sit Ups Test of Muscular Endurance of slum area school girls of experimental and control groups differs significantly where pre Bent Knee Test of Muscular Endurance of slum area school girls was taken as covariate.

TABLE 2

Summary of One Way ANCOVA of Muscular Endurance of Slum Area School Girls

Source of Variance	df	SS	MS	F	Remark
Group	**1**	**638.79**	**638.79**	**25.66**	**p<0.01**
Error	**97**	**2414.31**	**24.89**		
Total	**100**				

Thus, the null hypothesis that there is no significant difference in adjusted mean score of Bent Knee Sit UpsTest of Cardiovascular Endurance of slum area school girls of experimental and control groups by taking pre Bent Knee Sit Ups Test of Muscular Endurance of slum area school girls as covariate is rejected.Therefore the adjusted mean score of Bent Knee Sit Ups Test of Muscular Endurance of slum area school girls of experiment group is 23.80 which is significantly higher than of control group where adjusted mean score of Bent Knee Sit Ups Test of Muscular Endurance of slum area school girls is 18.14

Discussion

The purpose of the present study was to study the efficacy of yoga practices for the promotion ofMuscular Endurance of slum area school girls. It is appeared from the result of the present study that, the twelve weeks' yoga training programme has brought significant improvement in case of Muscular Endurance of slum area school girls. Though the results of the studies conducted by other researcher (Vinekar, 1957; Gharote, 1977, Bera&Rajapurkar, 1993, Moorthy, 1988; Hagins, Moore, & Rundle, 2007; Tracy & Hart, 2012; Madanmohan, et al, 2008; Chen, et al, 2009; Bera, T. K., 1999; Shrikrishna, 1990; Lagerberg., 2005; Bhole M. V.,1977; Hanumanthaiah, Nagarathna, &Nagendra, 1994; Gharote M. M., 2000; Gharote&Ganguly, 1989; Clay, et al, 2005; Sinha, Ray, Pathak, &Selvamurthy, 2004; Bussing, et al, 2012; Gruebner, et al, 2012; Kafle, et al 2010 and Goldfine&Nahas, 1993) are supporting up to some extent to the above stated findings of the present study.The probable reason for the significant improvement in case of Muscular Endurance is nothing but twelve weeks' intervention of yogic practices. To summarize, the results of the study proved beyond doubt that regular practice of yoga for one hour daily for '***Twelve Weeks'*** is beneficial in maintaining Heath Related Physical Fitness of the Slum Area School girls.

Conclusion

'12 Weeks Yoga Training Program' is helpful to improve Muscular Endurance of slum area school girls.

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