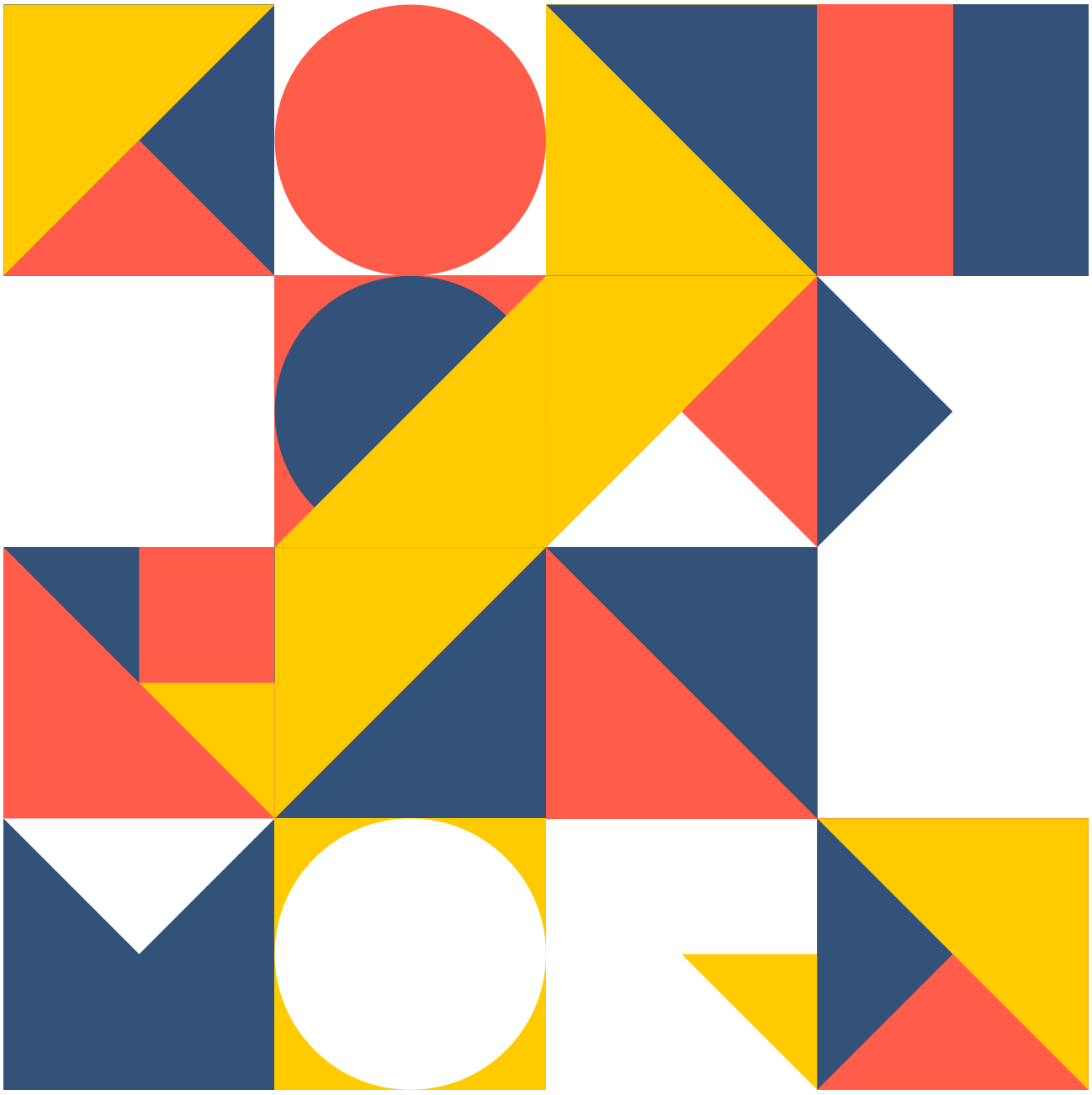
INTERWOVEN

An Interdisciplinary Journal of Navrachana University
e-ISSN (2581-9275)

NAVRACHANA UNIVERSITY

Volume - 1
Issue 1 & 2



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Published by

Navrachana University,
Vasna-Bhayali road,
Vadodara- 391 410,
Gujarat, India

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About Interwoven

Interwoven, Navrachana University's peer reviewed interdisciplinary journal, weaves together a wide range of ideas to offer a layered mosaic of scholarly work. Peer reviewed journals are essential for academic work as they bring new rigor to make corrections and also a completely new perspective to the proposed idea.

Interwoven offers a platform to present scholarly articles that are disciplinary and non-disciplinary, and engage in a rich academic discourse. Non-disciplinary articles, because of their generalistic content provide a means for all readers to find a common ground to connect and get involved regardless of their expertise. Disciplinary work, on the other hand, is presented in a form that non-disciplinary readers can read, understand and participate in an academic discourse to reflect, reinvent and expand traditional disciplinary boundaries.

Aim and Scope

Interwoven is a double blind peer reviewed interdisciplinary journal of Navrachana University, published online biannually. The journal covers inherently general topics as well as specialized topics written for readers from wide backgrounds. The effort is to build a strong interdisciplinary academic and research culture in the society.

Regarding review process, there is a strong criteria established for an article to be considered for revision, acceptance or rejection. Every article undergoes check for Plagiarism. Each article is reviewed by three referees.

Interwoven has been granted an e-ISSN number (2581-9275). We strongly encourage faculty, scientists, postdoctoral fellows and research scholars to contribute their scholarly work in the form of research articles, review articles, perspectives, critiques, book reviews and articles in social research. We look forward to expand our authors and readers network and set a benchmark in the process of growth for students, faculty, University and the society at large by spreading awareness about various knowledge domains. We also encourage undergraduate and postgraduate students involved in dissertation work to write journal articles and promote new research ideas to expand their vision beyond standard academic curriculum.

Interwoven Editorial Board

Index

This is an interactive PDF, tap/click on the paper titles to go to the article page. To navigate back to the index tap/click on the interwoven icon on the first or the last page of the article.

Volume 1 , Issue 1

Education

Mathematics

Social Science

Volume 1 , Issue 2

Education

Engineering

Volume - 1

Issue - 1

The Heart and Soul of School Curriculum

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Abstract

Although peace education has been defined in many ways, the scope for its clarity is still sought by the stakeholders of education. Schools are implicitly public service oriented. They are meant to serve the society. The paper focuses on the set of values to be demonstrated in the school's day to day functioning that would bring about peace and harmony not only in school but also in society it serves.. Teaching that occurs in school is considered as a tri-polar process that includes the learners foremost, teachers next and the content – be it knowledge related, motor skill related or attitude related – the essential third part. The author looks at some characteristics that ideally should be present in **learner, the teacher and the content** for peace values to be disseminated and why it forms the heart and soul of curriculum.

Keywords

peace education, teaching learning process, learning experiences

Introduction

Many researchers and educationalists have stressed the utmost relevance of educating our school going children for peace values. And so the concept of peace education has been studied diligently over the past few decades. Although peace education has been defined in many ways, the scope for its clarity is still sought by the stakeholders of education. It ought to be the heart and soul of school curriculum. The author too has here tried to conceptualize peace education, so that the curriculum adopted by schools can be studied from this perspective of peace education.

Schools are implicitly public service oriented. They are meant to serve the society. Whereas we find schools nowadays are becoming nurseries of competition, ensnaring investors instead of people deeply involved in education, over worked teachers who are made spend as much time documenting work on minute by minute basis as on classroom teaching, the curriculum acknowledging and supporting mainly science subjects and not humanities

and more such. In this scenario, schools have become more like corporate organizations. The systems and sub-systems of corporate organizations are mimicked in schools too. It has structural system which determines mission, vision, goals and objectives that could be unique to each school set up. It has the administrative system which comprises planning, organizing, controlling, and coordinating to help in smooth transaction of school curriculum. It also has a social system that includes all the personnel involved with the school and their communication with each other.

In the context of school, unlike corporate, desired achievement or success need not depend on just a 'system' type of functioning or on a set of policy for school discipline, it requires in place a set of values demonstrated in its day to day functioning that would bring about peace and harmony in school and outside school.

The school curriculum of any state is inherently meant to develop good human beings. It is needless to say that a 'curriculum' stands for all the activities that is carried out in the school premises and outside with the intention of educating the learners. Curriculum of school level education needs to promote peace values among the students. One needs to analyze whether the curricular and co- curricular activities conducted in school stress on peace values, whether the textbook content is utilized well in transaction of peace values, whether the 'hidden curriculum' finds a place in day to day teaching in schools. This paper tries to focus on the elements necessary for peace values in the teaching learning process that occurs in the classroom.

Transaction of Peace Values in Teaching Learning Process

Teaching is considered as a tri-polar process that includes the learners foremost, teachers next and the content – be it knowledge related, motor skill related or attitude related – the essential third part. Teaching is interplay of these three. In analogous manner the success of teaching peace values or peace education depends on certain ideal characteristics present in the individuals involved and a well defined curriculum which provides scope for transaction of peace values. Developing the whole child cannot happen when education in school entirely focuses only on the pursuit of conceptual and procedural knowledge ignoring the values inherent in them. It can neither happen if some basic characteristics are absent or considered insignificant in two set of individuals involved –the teacher and the student.

The following figure represents teaching or providing learning experiences as a tri-polar process, in which the three entities are constantly interacting.

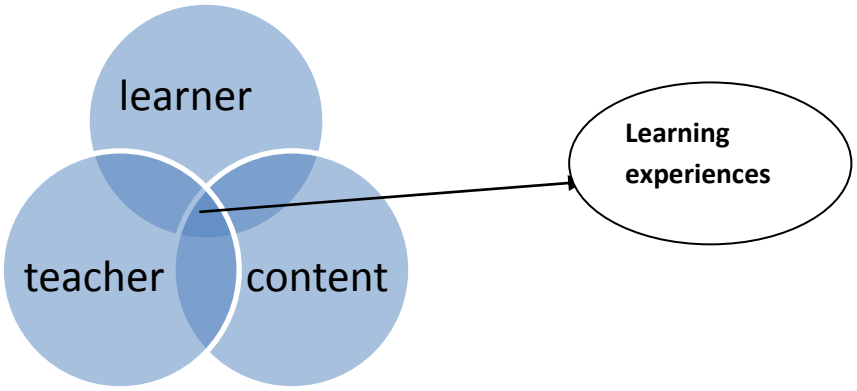

Figure 1: Learning experiences and peace values

Peace education, according to the author is an amalgamation of the qualities present in learners and teachers as well as the potency of content of the learning experiences. The content present in textbooks is as important as the various encounters between the learner and the teacher in curricular and co- curricular activities. The interchanges among the learners and teacher offers scope to identify instances that promote peace values among children. They can move from personal scale to school, community and global scale in a widening sphere of influence. ‘A teacher who is oriented to the perspective of peace can introduce such opportunities for reflecting at these scales and identifying the inter linkages between them (NCERT, 2005).

Characteristics Essential in Learner

The author suggests the following characteristics ideally be present in **learner** for peace values to be perceptible. They are

1. **Taking initiative**

   The psychological environment of classroom is crucial in supporting a peace oriented behavior among students. The interest and desire to learn motivates children to take initiatives in class. They can be demonstrated by children in the class in many ways.
2. **Integrity**

   Truthfulness and sincerity in doing the tasks helps children achieve success. It is a quality which promotes satisfaction from accomplished tasks and in turn peace of mind.

3. **Responsibility**

   Being conscious of one's responsibility in following the collective goal of the group is conducive to state of peace.

4. **Sense of respect**

   Respect for teachers and valuing the knowledge gained creates the ground for bettering oneself and feel successful.

5. **Cooperation**

   Classroom tasks require cooperation among the learners. When unable to make friends in a group the child becomes an isolate and gets frustrated and quarrelsome. Children are by nature friendly and sociable. It has to be capitalized by the teacher by giving group tasks so that they learn to live in harmony with others

6. **Flexibility**

   The classroom is a dynamic place and one should have an open mind and resilience to accommodate the unprecedented or the unexpected. This is another quality if developed in learners will promotes peace.

7. **Industriousness**

Remaining active and efficient in class tasks helps child to learn better and succeed. Assigned work ought to promptly taken up and diligently completed to the satisfaction of the teachers. It is conducive to nurture of peace values.

Characteristics Essential in Teachers

The author suggests the following characteristics ideally be present in **teachers** for peace values to be perceptible. They are

1. **Resourcefulness**

   Classrooms can be challenging sometimes, and unless the teacher is resourceful and innovative she will not be able to manage the teaching learning process. The incidents that occur in class as well as the textbook material can become instrumental in the hands of the teacher for conveying peace values and their importance.

2. **Fairness**

   Children expect teachers to be fair and reasonable with them. When teacher treats all her students equally according to the existing rules it enhances the perception of peace.

3. **Vigilance**

   Teacher has to be very observant to tackle the budding problems. Vigilance and timely action on the part of the teacher can reduce the flare up of disruptions and consequently maintain the peace in the class.

4. **Self efficacy**

   Confidence and belief in completing the tasks and the fulfillment of the learning objectives improves the self efficacy of teachers in dealing with problems of classrooms. The teacher has to think about continuous improvement in the service offered by her.

5. **Future Vision**

   Just as a brick layer envisions the final structure, the teacher need to focus on the end product that would be created through her guidance. If creation of humane individuals is the vision a teacher has then the classroom would be a place where they are nurtured

6. **Responsibility**

   A teachers' responsibility extends beyond the classrooms. She is a care-taker in the true sense. Safeguarding the interests of her wards is foremost duty and its execution brings harmony in the class. Sincerity and hard work are outcomes of a feeling of thoughtful responsibility. It extends to working with colleagues for the purpose of achieving the school goals.

Characteristics Essential in Learning Experiences and Learning Materials

The author suggests that the **learning experiences and learning materials** need to project the following characteristics for peace values to be perceptible. They are

1. **Relevance to times**

   Providing such experiences keeping with current times is required for students to tackle future problems.

2. **3Hs – head, heart and hands**

   The curricular activities which have been for convenience bifurcated into curricular and co- curricular activities but essentially they are designed to develop the 3Hs – head, heart and hands

3. **Embracing the entire world**

   Diversity is universal; differences in culture can be unified under the surface with compassion and understanding. Acceptance of all is the key to peace in world.

4. **Utility to self**

   Experiences that benefit is always sought by people and understanding how learning experiences shape one's thought and actions bring satisfaction.

5. **Promote optimism**

   Any curricular activity has to have an innate sense of optimism, as humans always aspire to create a better world.

Discussion

The idea of peace education is as wide as any topic in the field of education. Education at all levels needs to include peace perspective in curriculum. It is valid concern as mankind has ignored the perspective of peace in the education of its youngsters. That is why youth coming out of schools and colleges are unable to face challenges in the real world. They show more aggression whether it is home, workplace or community. They have less understanding about how to lead a harmonious and peaceful life. Formal education system tends to emphasize the acquisition of knowledge to the detriment of other types of learning. But it is vital now to conceive education in more encompassing fashion. The purpose of education can be served only if there is a well planned and well drawn out curriculum which would bring about an all round development in the individual – his mental, physical and emotional well being. In other words it is creation of good human beings with peace and love in their hearts and mind.

Conclusion

Creating a world where peace and harmony begins with the children. In the words of Mahatma Gandhi "if we are to teach real peace in this world and if we are to carry on a real war against war, we shall have to begin with the children." If school curriculum gives a central place to peace we shall have a better world in the future. Educating for peace is distinctive approach in transforming education by addressing the present lacuna or shortcomings of school education. The idea of peace education is grounded in ideals of social justice, equal access and sustainability. It is the schools that adopt progressive and relevant

changes bring social transformation and so peace education ought to be the heart and soul of school curriculum.

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Resolving Vectors

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Abstract

Static or dynamic state of any object is the result of various forces acting on it. To correlate the state of the object mathematically with the forces, one need to analyse opposing forces and complimentary forces by the process of 'Vector Resolution', meaning breaking of a vector in two components perpendicular to each other. One has to then write governing equilibrium or force balancing equations and derive the formulae for the object's motion. Present article emphasizes the very simple fact that there are no sacred directions along which the force vectors should be resolved. The key step is to draw a rectangle with given force vector along its diagonal and orienting the rectangle in such a way that its sides should be parallel (or anti-parallel) with other force vectors acting on the object. This unified method has been illustrated by different examples in the article.

Keywords

Vectors, resolution of vectors, classroom teaching

Introduction

Any physical quantity that requires magnitude as well as direction for its interpretation is called as a vector. In daily life, often one needs to use judgement to find which way a big carton is to be pushed/pulled/lifted in order to relocate it from one place to another. In cricket, a bowler needs to use a judgement as to how the ball needs to be thrown so that it reaches the batsman in the most complicated manner. Although in both these examples, neither a worker nor a bowler takes a break and calculate the force to be applied or how the ball is to be thrown. The action taken normally depends on a quick strategy which gets developed with experience and practice!

For science and engineering practitioners, it is of utmost importance to understand role of vectorial quantities and how to deal with them. While teaching many analytical topics one often needs to begin with equilibrium equations and derive further. A common

observation is that students either don't understand how to deal with various force vectors to find resultant or they just accept what is written in the books. If the students cannot derive these conditions from scratch then they end up memorizing the salient steps which leads to 'Volatile Learning'.

Present article discusses concepts taught in classrooms to first or second year undergraduate students. The article will first focus on additions/subtractions of vectors. Then common methods to resolve vectors into two components will be discussed. A few examples discussed in the article represent how a single parallelogram method of vector resolution can be used in solving any problem involving force vectors.

Discussion

Combination of Vectors- Addition & Subtraction:

Two or more vectors can add with or subtract from each other to give a final resultant vector. However, addition or subtraction of vectors is done in a graphical way. 'Scalar' quantities which do not require direction for their description along with magnitude, can be added or subtracted quickly in mind to get a final estimate. But it is not obvious to guess how a resultant of two given vectors will look like unless you draw them on paper. The operator of addition or subtraction can be simply done by graphical method. For addition of two vectors $\vec{A}$ and $\vec{B}$, tail of vector $\vec{B}$ should be placed on head of vector $\vec{A}$. Now draw a new vector with its tail from tail of vector $\vec{A}$ to head of vector $\vec{B}$. When vector $\vec{B}$ is to be subtracted from vector $\vec{A}$, first reverse the direction of vector $\vec{B}$ and then place tail of inverted vector $\vec{B}$ on head of vector $\vec{A}$. Next to find the resultant vector draw a new vector from tail of vector $\vec{A}$ to head to inverted vector $\vec{B}$. Figure 1 shows an example of the vector addition and subtraction.

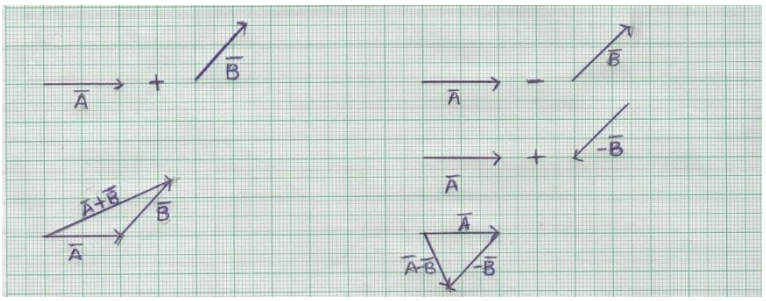


Figure 1: Addition and Subtraction of vectors

Resolution of Vectors:

Every vector can be represented as addition of two perpendicular vector components. Most of the times, we want to know how a given vector can be written as a sum of horizontal and vertical vector components in the plane containing the vector. There are two methods (1) trigonometry method and (2) parallelogram method as shown below in figure 2.

(a) **(b)**

Figure 2: (a) Trigonometry method (b) Parallelogram method

In trigonometry method as shown in figure 2(a), the given vector needs to be the resultant of addition of two vectors perpendicular to each other. In parallelogram method (fig. 2(b)), a rectangular parallelogram is built around the given vector in such a way that the given vector is along the diagonal to the rectangle. The height and width of the rectangle form the two components of the given vector. Now the question is whether resolution of vector means to break the given vector in horizontal and vertical components? The answer is 'NO'. It is very important to realize that for a given vector there are infinite possibilities to draw a rectangle having the given vector along its diagonal (figure 3).

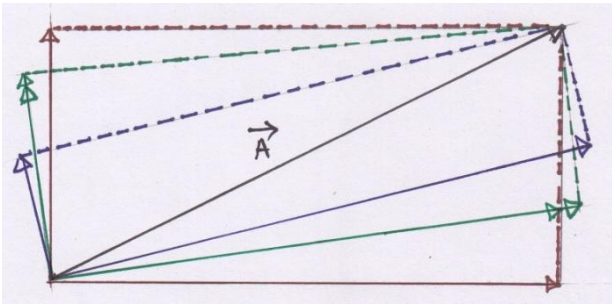
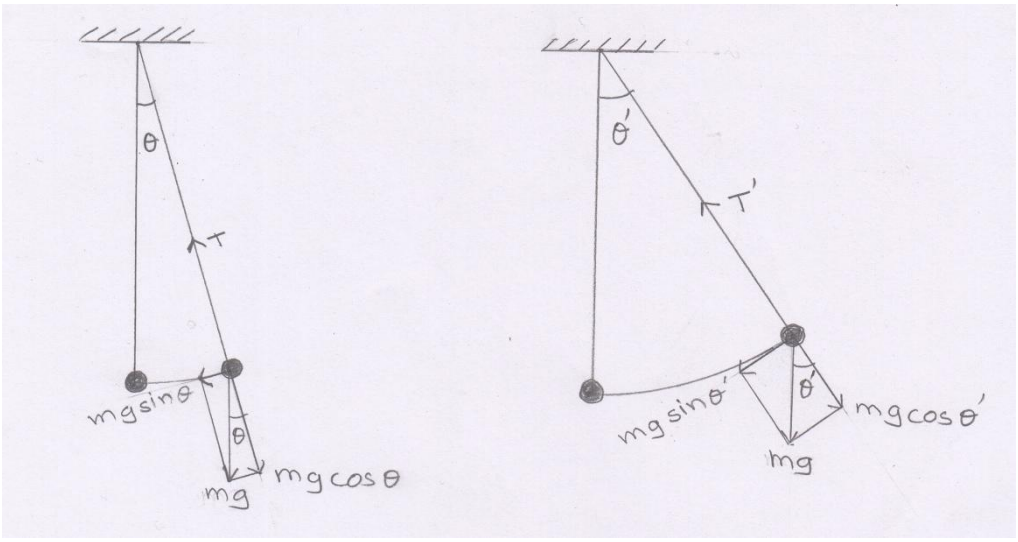


Figure 3: Parallelogram method showing many possibilities of rectangles for the same diagonal vector

As shown in figure 3, like red, green, blue, one can draw a number of rectangles with a given vector along the diagonal. So technically, $\vec{A}$ can be written as a resultant of any pair of red, green or blue vectors and not just the horizontal and vertical (red) vectors. Note that the magnitudes and directions of vector components can be different depending upon which rectangle we choose for diagonal formation. So then the question is which way the vectors need to be resolved. The answer is that one should resolve the given vector in those two perpendicular components which help in solving equilibrium conditions in free body diagram. This point is illustrated below by taking four examples.

1. *Oscillation of a simple pendulum*[1]*:*



(a) **(b)**

Figure 4: (a) Pendulum slightly away from equilibrium position (small θ) and (b) Pendulum far away from equilibrium position (large θ')

Both the above figures show oscillatory motion of a simple pendulum with free body diagrams. In both (a) and (b), the gravitational force (weight) acts in the pendulum vertically downward direction but we choose to resolve the weight vector along two different perpendicular components in such a way that one of the components is along opposite of one of the tension force T in the string and the other component is responsible to move the pendulum towards the centre.

As shown in figure 4(a) and (b), the weight force is resolved into two perpendicular components such that cos θ component is opposite to the tension force in the string.

However, as the pendulum moves from the central position towards extreme position, the angle the gravitational force makes with the string increases, which leads to increase in the sin θ component.

$$T = mg\cos\theta$$
$$mg\sin\theta = ma$$

Physical significance of resolved vectors:

a. Tension in the string tied to an oscillating simple pendulum is not same at all positions of the pendulum. It reduces as the pendulum moves away from the central position.
b. The restoring force acing on the pendulum to bring it back increases as the pendulum moves away from the central position and is maximum when in the extreme position pertaining to maximum value of mg sin θ.

2. *Wooden box sliding on an inclined plane with reasonable friction*[1]*:*

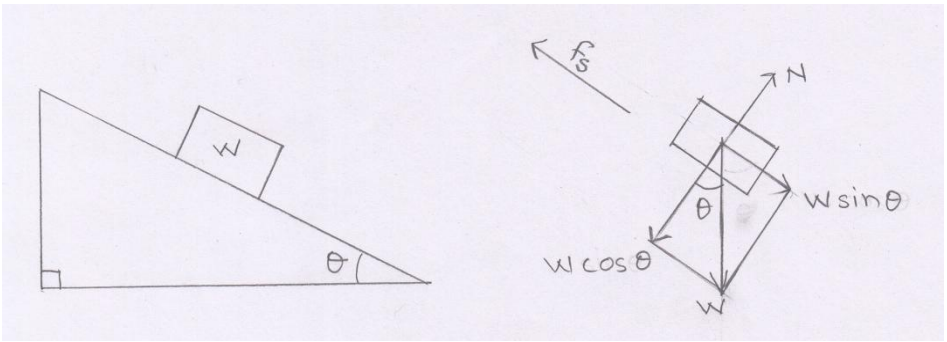


Figure 5: Wooden box on inclined plane and its free body diagram

Since the block is moving along the inclined surface, the normal reaction has to balance the W cosθ component of the gravitational force. Since the block is sliding down wards, the frictional force which acts parallel to the surface and opposite to the motion does not balance the W sinθ component of the gravitational force.

$$W\sin\theta - f_s = ma$$
$$W\sin\theta - \mu N = ma$$
$$N = W\cos\theta$$

Physical significance of resolved vectors:

a. If the normal reaction is more than $W\cos\theta$ component the block will lift above the surface while sliding.
b. If the coefficient of friction is sufficiently large, then it is possible that the block does not slide at all. The sliding can be stopped even when the angle of inclination becomes less.

3. Stress on an inclined section[2]:

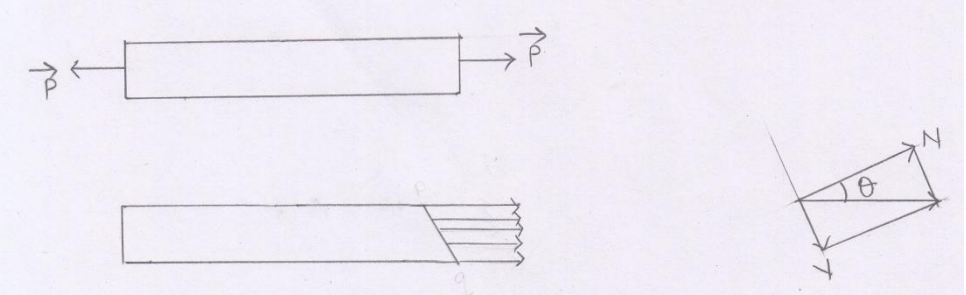


Figure 6: Normal force (N) and shear force (V) acting on an intermediate inclined section of a prismatic bar under tensile load

Consider a homogeneous, prismatic bar with rectangular cross-section being subjected to tensile load. Imagine what kinds of stresses are present at an inclined surface. For equilibrium of the bar, the applied load P at the left end and the developed force due to stress at the right has to balance each other. This developed stress gets uniformly distributed over any cut section surface along the horizontal line. So the equivalent load P acting on the inclined surface pq can be resolved in two vectors N and V. Force N acts along the perpendicular direction to the inclined surface and force V parallel to the surface pq.

Physical significance of resolved vectors:

Even though the rectangular bar is subjected to tensile load along the axis of the bar, on an intermediately cut inclined section, there are two kinds of stresses present, normal stress σ_θ and shear stress τ_θ. Note that the perpendicular component N is responsible for the tensile/normal stress σ_θ and parallel component V is responsible for the shear stress τ_θ.

4. Forces acting on soap bubbles[3]:

A soap bubble can be modelled in the form of a spherical shell. As shown in figure 8, there are three types of forces acting on the bubble. (i) Force due to outside air acting radially inwards (ii) Force due to air inside acting radially outwards and (iii) force due to surface tension along horizontal axis. In order to find resultant of force due to outside air, one has to resolve each force vector along two components, one horizontal $P_1 \Delta S \cos\theta$ and one vertical $P_1 \Delta S \sin\theta$. When considered over the entire spherical surface, all the vertical components get cancelled out and only the horizontal components survive. The horizontal components $P_1 \Delta S \cos\theta$ due to all area elements of the spherical shell need to be added up. But $\Delta S \cos\theta$ is projection of area element of the hemisphere on the circular vertical plane passing through the diameter of the sphere. So when all the area elements of the hemispherical surface are projected, one gets the circular plane itself. So the force acting on the bubble due to outside air is equal to $P_1(\pi r^2)$, where r is the radius of the sphere. The same trick can be used to determine force acting on the shell due to air inside the shell.

Physical significance of resolution of vectors:

The resolved horizontal component acting on all area elements needs to be taken throughout the hemispherical surface and later integrated. Or the effective area is to be considered as the circular cross-sectional area of the spherical shell and the pressure acting on the area is to be taken as P_1.

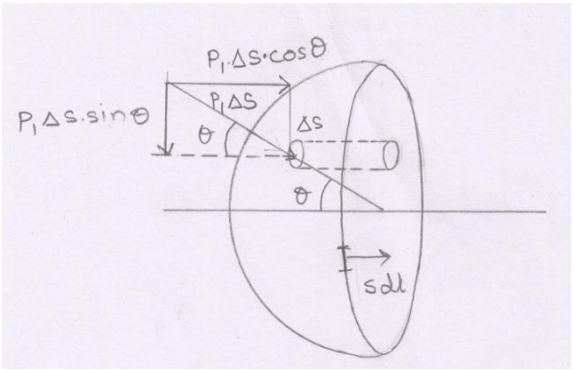


Figure 7: A hemispherical shell of a soap bubble showing force acting on it due to outside air and surface tension

Suggestions

A take home message from this article for the students is to understand the basic steps to resolve a given vector in two perpendicular vector components by parallelogram method. The two components or the sides of the rectangle are to be chosen in such a way that they are either parallel or anti parallel to other vectors in the free body diagram. Identify the angle the vector makes with the sides of the rectangle and find out the magnitudes of the vector components. These component values can then be used in equilibrium or balancing equations to get final answer. These simple steps can also serve as teaching pedagogy for teaching relevant topics.

Acknowledgement

Author would like to thank Ms. Aashna Jain for preparing some illustrations in the article.

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Construction of Fibonacci Spiral and Geometry in Golden Hexagon using Golden Sections

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Abstract

In this article, various geometry and construction of Fibonacci spiral is drawn in golden hexagon using golden section. Mathematical properties of the constructed geometry may be investigated. The above is the novel work of the present article. The article gives introduction to golden ratio and golden spiral. For beginners, as instruction guide for construction of various geometrical basics shapes such as, golden rectangle, golden triangle, golden rectangle spiral and golden triangle spiral, golden pentagon and golden hexagon is given. Article includes also the couple of examples in nature, paintings, and sculptures with superimposed images which are correlated with present geometrical construction of basic shapes.

Keywords

Golden section, Golden hexagon, Golden ratio

Introduction

Golden ratio is an irrational number that's equal to approximately 1.6180 and is written by Greek letter φ. When we divide a line into two parts such that the whole length is divided by the long part is also equal to the long part divided by the short part[1].

Figure 1: Golden Line

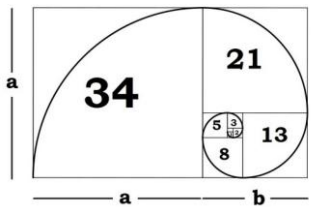


Figure 2: Golden Rectangle

Figure 3: The Great Pyramid

Here,

$$\frac{AB}{AC} = \frac{AC}{CB} \cong 1.6180 \tag{1}$$

Artists and architects believe that the golden ratio makes the most pleasing and beautiful shape.

Besides being beautiful the resulting shape has interesting characteristics.

The golden number can be applied to the proportions of a rectangle, called the golden rectangle, other basic geometric shapes such as triangles; pentagons; hexagons etc… This is known as one of the most visually satisfying of all geometric forms. Hence,the appearance of the Golden Ratio in Art. If you draw a golden rectangle, and then draw line inside it to divide that rectangle into a square and another smaller rectangle, that smaller rectangle will amazingly be another golden rectangle. You can do this again with this new golden rectangle, and you will get once again a square and yet another golden rectangle (Fig. 2). This process can continue till infinite. Mathematically, this property is visualized in following equation in terms of continued fraction[2],

$$\varphi = 1 + \frac{1}{\varphi} \qquad \text{or} \qquad \varphi^2 - \varphi - 1 = 0 \tag{2}$$

Here,

$$\frac{a}{b} = \frac{(a+b)}{a} \cong 1.6180 = \varphi \tag{3}$$

Many buildings and artworks have the golden ration in them, such as The Great Pyramid, the Parthenon in Greece, but it is not really known if it was designed that way. In Great Pyramid of Giza, (Fig. 3), the length of each side of the base is 756 feet with a height of 481 feet. The ratio of the base to the height is roughly 1.5717, which is close to the Golden Ratio. Leonardo da Vinci used the Golden ratio to define all of the proportions in his creations.

Around, 1200, mathematician Leonardo Fibonacci discovered the unique properties of Fibonacci sequence. This sequence ties directly into the Golden Ratio.

Fibonacci sequence is the series of number 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, ...

The next number in the Fibonacci sequence is found by adding up the two numbers before it. Here, connection between the Golden ratio and the Fibonacci sequence is given by dividing each number in the Fibonacci sequence by the previous number in the sequence, gives: 1/1 = 1, 2/1 =, 3/2 = 1.5, and 144/89 = 1.6179...., number reaches a closer approximation of the golden ratio φ and getting closer and closer to 1.6180[3].

The Golden and Fibonacci Spiral

The celebrated golden spiral is a special case of the more general logarithmic spiral whose radius r is given by[4]

$$r = ae^{b\theta} \tag{4}$$

Where θ is the usual polar angle, and a and b are constants. Jacob Bernoulli (1655 – 1705) studies this spiral in depth and gave it the name spira mirabilis, or miraculous spiral. The golden spiral is a logarithmic spiral whose radius either increases or decreases by a factor of the golden ratio φ with each one – quarter turn, that is, when θ increases by $\frac{\pi}{2}$.

The golden spiral therefore satisfies the equation

$$r = a\varphi^{\frac{2\theta}{\pi}} \tag{5}$$

In fig. 2, within the golden rectangle, the dimension of each succeeding square decreases by a factor of φ, with four squares composing each quarter turn of the spiral. It is then possible to inscribe a golden spiral within the figure of golden rectangle with spiralling squares. The central point of the spiral at the accumulation point of all the squares, and fit the parameter a so that the golden spiral passes through opposite corners of the squares.

A Fibonacci spiral approximates the golden spiral using quarter – circle arcs inscribed in squares of integer Fibonacci – number side, shown for square sizes 1, 1, 2, 3, 5, 8, 13, 21, and 34. The resulting Fibonacci spiral is shown in Fig. 2.

Geometrical Construction of Golden Rectangle, Golden Triangle, Golden Pentagon and Golden Hexagon

In this section, the geometrical construction of Golden Rectangle is described[5].

Geometrical Construction of Golden Rectangle

A golden rectangle is a rectangle with side lengths that are in the golden ratio (about 1:1.618). This section also explains how to construct a square, which is needed to construct a golden rectangle.[5]Step 1: Draw a square. Let us name the vertices of the square as A, B, C and D.

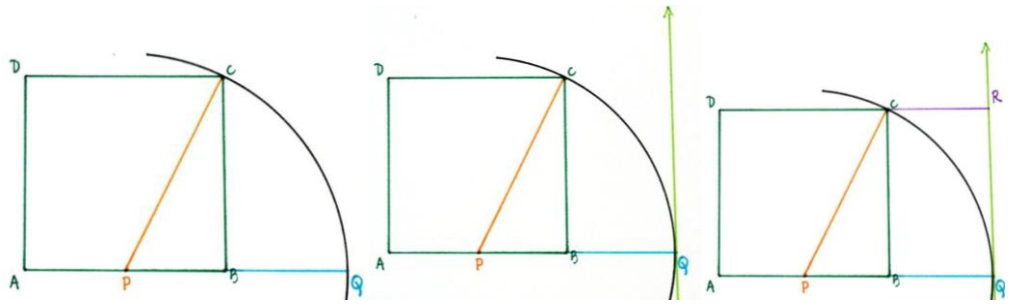


Figure 4: (a, b, c) Golden Rectangle

Step 2: Locate the mid-point of any one side of the square by bisecting it. Let us pick the side AB and call its mid-point as point P. Step 3: Connect the mid-point P to a corner of the opposite side. Since P lies on the side AB, the opposite side shall be the side CD. Let's choose to connect P with C. Step 4: Place the tip of the compass on P and set its width to match the distance PC. Draw a large arc towards the side BC. Step 5: Extend the side AB to cut the arc at some point (say Q).Step 6: Draw a line parallel to the side BC, passing through the point Q. Step 7: Extend the side DC to meet the parallel line at some point (say R). Step 8: Erase any extraneous constructions if you so wish. You may verify that the ratio of the measure of the shorter side of the rectangle (QR or AD) to the measure of its longer side (AQ or RD) is very close to 1:1.618. Further the rectangle CRQB is another golden rectangle, in which another square is made of length BQ gives us third golden rectangle inside CRQB and the process continues. (Fig. 4 (a, b, c)).

Golden line, rectangle and spiral Examples

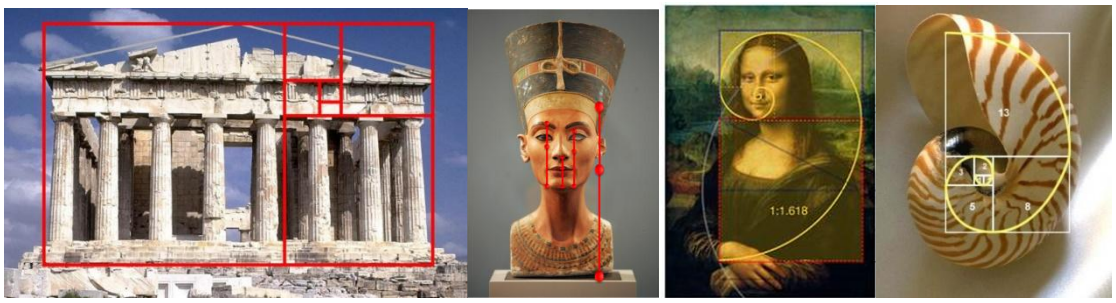
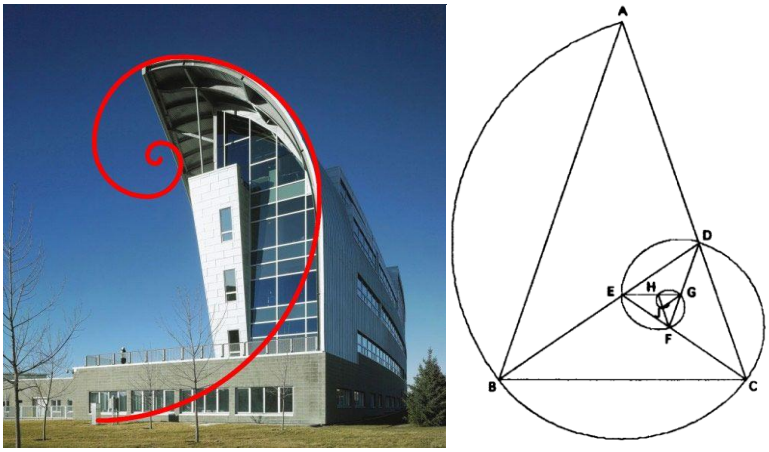


Figure: 5 (a, b, c, d) Golden Ratio in real life

Fig. 5a shows the famous monument Parthenon in Greece,the golden section used in the Ancient Egypt sculpture is seen in Fig. 5b.

Construction of Golden Rectangle Spiral[7]

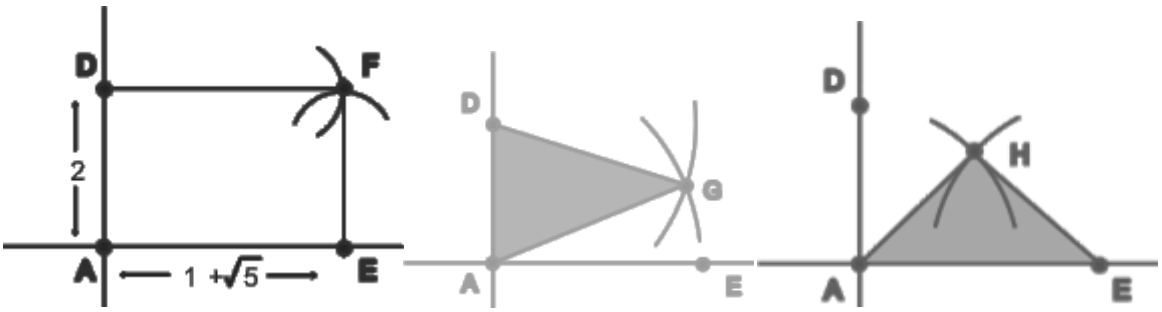
To draw a golden spiral, consider the centre of the square C and radius CD for the one turn of the spiral. Similarly, various centres and radius are obtained for all squares and using quarter – circle arcs inscribed in squares, the spiral is completed as shown in Fig. 2. Golden section, rectangle and spiral is seen in paintings, sculptures, building, nature (egg shell), human DNA molecule etc…Fig. 5c, 5d - f.



(e) (f)

Figure 5: Golden rectangles and triangle spiral

Construction of Golden Triangle and Golden Triangle Spiral



(a) (b) (c)

Figure 6: Construction of golden triangle

Draw golden rectangle using the method as described in above section. As shown in Fig. 6a, the golden rectangle has longer side as (1 + √5 units) and shorter side as 2 units. Draw twointersecting arcs of radius the length of *AE*. One with compass point at point *A* and the other with compass point at point *D*. Label the point of intersection *G*. The triangle *ADG* is a golden triangle; it is an isosceles triangle (Fig. 5f) with the ratio of the longer side (1 + √5 units) to the shorter side (2 units) equalling the golden ratio.(Fig.6b).[6]Alternatively you may construct a golden triangle by drawing two arcs of radius length*AD*, one centred at point *A* and the other centred at point *E*. Label the point of intersection of the arcs *H*. (Fig. 6c).Smaller triangles inside the big golden triangle are obtained by bisecting the angles for example, angles B and C, angles D and C, E and D, E and F etc… as shown in Fig. 5(f). For drawing the spiral in golden triangles, draw and arc of AB by considering the circle centre at D, draw arc BC considering the circle centre, draw arc CD by considering the circle centre at F, draw arc DE by considering the circle centre at G, draw arc EF by considering the circle centre at H, draw an arc of FG by considering circle centre at J (Fig.5f).[7]

Construction of Golden Pentagon

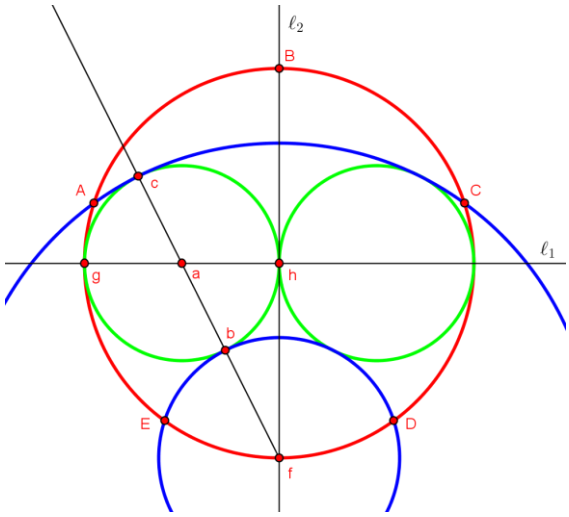
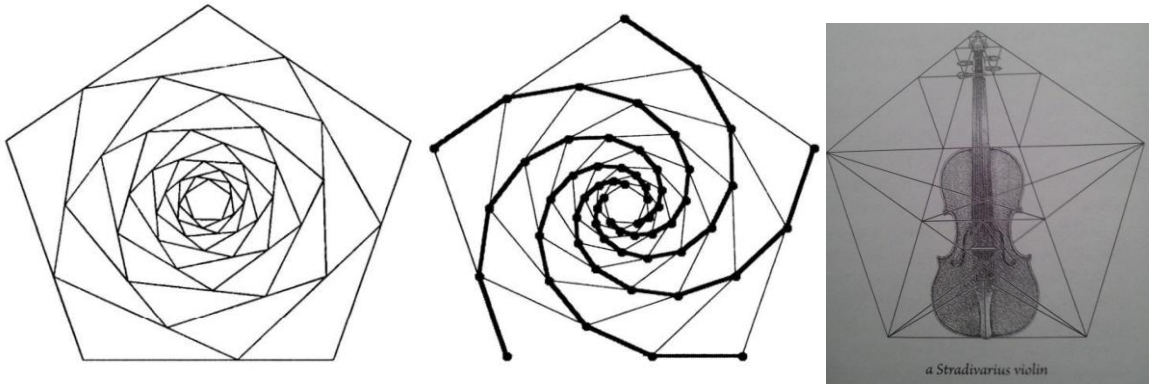


Figure 7a: Golden Pentagon

Constructing golden pentagon comes from Yosifusa Hirano of 19th Century Japan. It is elegant method of constructing the pentagon.[8] The following are the steps.1) Draw a circle (the red one) with center hh.2) Draw the perpendicular lines ℓ1ℓ1 and ℓ2ℓ2 through hh. Locate the points of intersection ff, BB, and ggwith the red circle.3) Bisect the line segment ghgh. Denote the center by aa.4) Draw the green circle with center aa and radius ahah.5) Draw the other green circle (as in steps (3) and 4)).6) Draw the line segment

through ff and aa.7) Locate the points of intersection bb and cc of the line segment with the circle constructed in step 4).8) Draw the blue arcs (both have center at ff and the radii are fbfb and fcfc).9) Locate the points of intersection AA, CC, DD, and EE.



(b) (c) (d)

Figure 7bcd: Golden Pentagon

Fig. (7b-c) shows a design made from golden pentagon as well as it is correlated with musical instrument in fig. 7d.

Construction of Golden Hexagon

Consider an equilateral triangle ABC as shown in Fig. 8. Let the points E, D and G on each sides of the triangle such as

$$\frac{CE}{EA} = \frac{BD}{DC} = \frac{AG}{GB} = \varphi \qquad (1)$$

Construct triangle EDG inside triangle ABC.In triangle EDG, Obtain points I, j and k in such a way EI = ID, EJ=JG, DK=KG.Also, draw line passing through vertex C and a point I intersects at line AB at point M, similarly, draw line passing through vertex B and point k which interacts line AC at point **K.** Similarly, also draw line passing through the vertex A and point j which intersects line CD at L. (Fig. 8) Construct hexagon KDLGMEK (Fig. 8) for which

$$\frac{KD}{KE} = \frac{EM}{MG} = \frac{GL}{LD} = \phi .$$

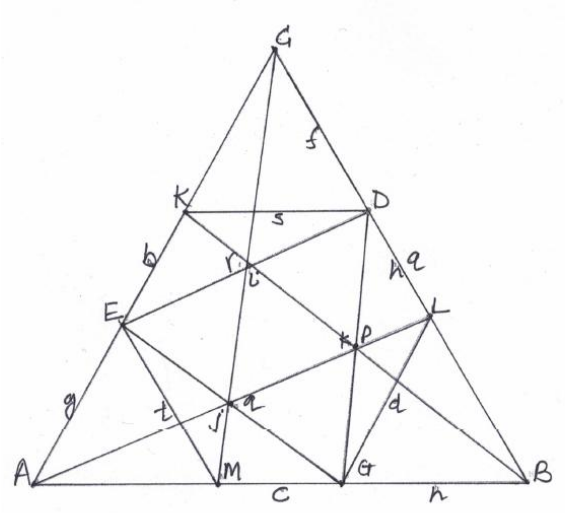


Figure 8: Construction of Hexagon

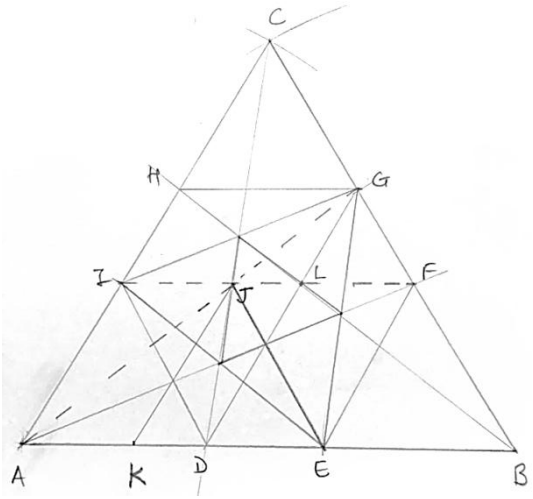


Figure 9: Golden section in golden hexagon

Construction of Geometry

Construct golden hexagon DEFGHI inside equilateral triangle ABC as shown in Fig. 9.Join IF to make parallelogram of AEFI.The lines AG, CD and IF meet at J, where now IJDE completes another parallelogram inside larger parallelogram AEFI. Join line JE to complete the smaller parallelogram DEJI.

On line AD, obtain point K in such a way $\frac{AK}{KD} = \varphi = \frac{AD}{AK}$.

Join JK such that JKE gives one triangle. Join DG and HB and intersection of these lines with IF meets at L where

$\frac{FL}{LJ} = \varphi = \frac{FJ}{FL}$ and EJF completes the triangle.

Here, naturally the intersection of lines IF and AG intersection at J, wherein $\frac{IJ}{JL} = \varphi = \frac{IL}{IJ}$.

This is the base line of the triangle DLI.

Construction of Spiral

Intersection of lines KJ from triangle KJE, The diagonal line of parallelogram DEJI, gives point M,Similarly intersection of lineDL from triangle DLI and the diagonal IE gives N.(Fig. 10)

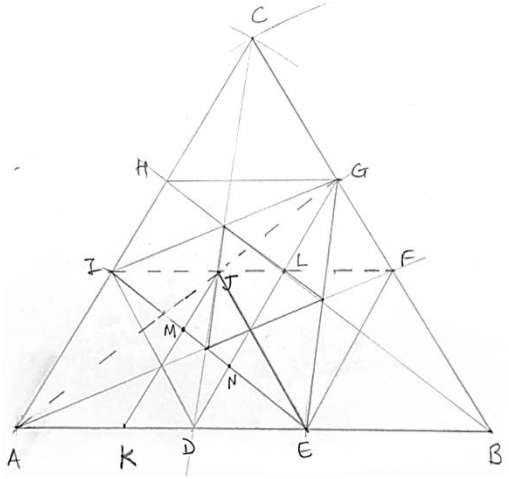


Figure 10: Marking golden sections

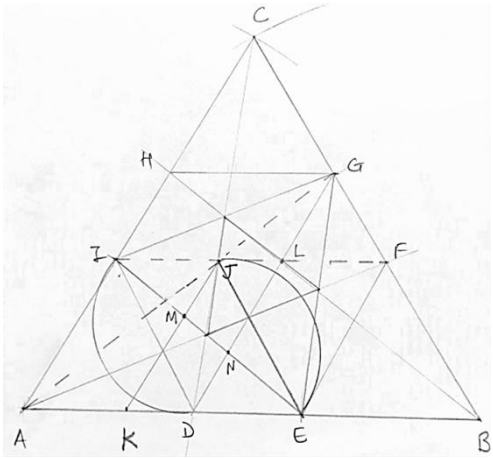


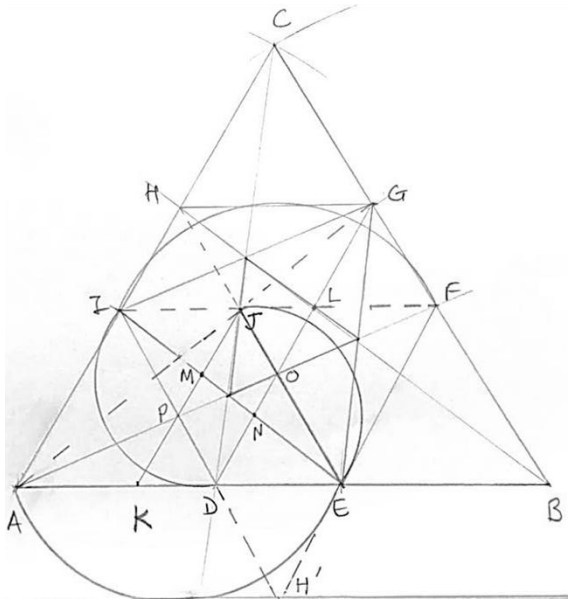
Figure 11: Obtaining locations and sections

Complete the part of spiral of arc length MI from M covering the side ID of triangle ADI and triangle DLI.Complete the part of spiral of arc length NE from N covering the side JE of triangle EFJ and KEJ (Fig. 11).

From larger parallelogram, obtain intersection of lines AF and line JE of triangle EFJ as well as intersection of lines ID and AF meets at points O and P respectively. Complete the spiral of arc length OF and AP covering sides FI and AE. Here, it is possible to imagine a larger triangle AEH as well as triangle of base length IF wherein virtual point of the triangle can be imagined H' passing through the lines ID and FE.

Here, it can be observed from Fig. 12 that $\frac{JP}{JM} = \frac{JM}{MP} = \varphi$, $\frac{DO}{DN} = \frac{DN}{NO} = \varphi$.

Now Imagine a parallelogram DOJP and NOMP.



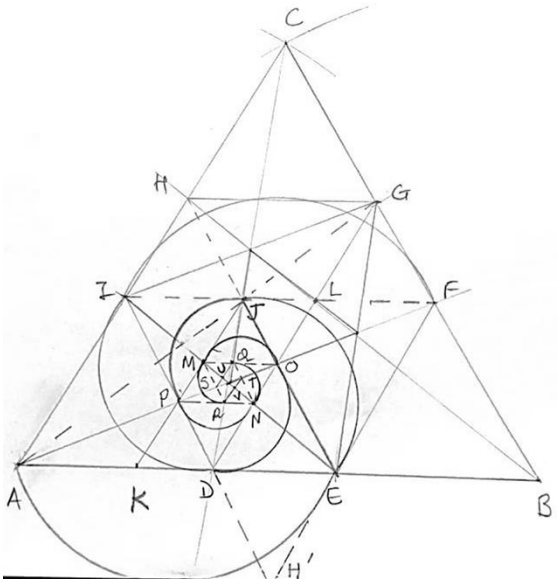


Figure 12: Construction of Golden Spiral Figure 13: Complete Spiral in golden hexagon

Parallelogram DOJP

Consider DOJP. Connect MO and PN to obtain triangle MOJ and DNP. Intersection of line DC cuts the triangle of line MO and PN to obtain points Q and R respectively. Line JD is a diagonal of parallelogram DOJP.In parallelogram, DOJP, draw an arc of length QJ from Q and RD from R covering the triangle PJI of side PJ and triangle DOE of sides DO (Fig. 13).

ParallelogramNOMP

Consider PNOM which has diagonal PO. Complete the triangle PRM and NOQ by connection M and R and QN to obtain lines MR and QN which intersects diagonal POat S and T respectively. Complete the arc of length TO and PS from T and S respectively covering the sides MO of triangle MOJ and PN of triangle DNP (Fig. 13).

Parallelogram RNQM

Consider RNQM which has the diagonal MN. Complete MSQ and RTN triangle in such a way one of the sides of the triangle intersects MN at U and V respectively.Complete the arc of length MU and NV from U and V covering the sides of the triangle PMR and QON. This completes the spiral (Fig. 13).Since golden ratio has the continued and infinite properties, it is true for golden hexagon and parallelogram inside golden hexagon follows this property of continued and infinite ratios.

Conclusion

Systematic construction steps of geometry and Fibonacci spiral has been presented in this article. The mathematical and geometrical properties may be investigated using these constructions. The design presented in this article is useful for artists, architects and mathematicians for further exploration. The method is applicable at any scale, micro to macro, but in any and all scales construction, the golden ratio whereever appears remains the same and constant. It is a general method, not for specific case such as 8/5=1.6180. This method is valid for any construction parameters of geometry. Irregular golden section hexagon is not common geometrical shape and has not been used in building proportions study. The reason for this is its difficult construction unlike many other well known basic shapes such as golden rectangles and golden triangles. The designer can think of a design by incorporating this shape in their construction including the spiral in golden section either in the form of symmetry and where optimized shape becomes the necessity for saving the space. A shape presented here can be a cross section of building and three dimensional objects. One such situation is occurred in platonic solids, where 4 vertices of icosahedron is golden rectangle.

Acknowledgement

Author would like to express a sincere thanks and gratitude to Navrachana University and especially to Prof. Abir Mullick, Provost, NUV for giving the support, encouragement and an opportunity to carry out this work. This work is an outcome of the interdisciplinary course Maths and Pattern.

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Construction of Golden Hexagon with golden section in equilateral Triangle

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Abstract

In this article, the golden section is related with equilateral triangle and golden hexagons. Simple construction method for making golden ratio hexagon is presented from equilateral triangle with golden sections on each triangle lengths. From the method, golden sections and golden ratio appears in hexagon for which ratio of two irregular sides of hexagon gives the value of golden ratio phi. The motivation behind this work is: it is important to learn about phi φ which is mathematically more challenged, its application to geometry and mathematics.

Keywords

Golden sections, Golden ratio, Golden Hexagon, Geometry and Graphics

Introduction

Golden ratio is an irrational number that's equal to approximately 1.6180 and is written by Greek letter φ. When we divide a line into two parts such that the whole length is divided by the long part is also equal to the long part divided by the short part. For example,

$$\frac{AB}{AC} = \frac{AC}{CB} = \varphi \cong 1.6180 \quad (1)$$

Geometry and Proof

Consider an equilateral triangle ABC as shown in Fig. 1. Let the points E, D and G on each sides of the triangle such as[2]

$$\frac{CE}{EA} = \frac{BD}{DC} = \frac{AG}{GB} = \varphi \tag{2}$$

Where φ [3] is the golden ratio.

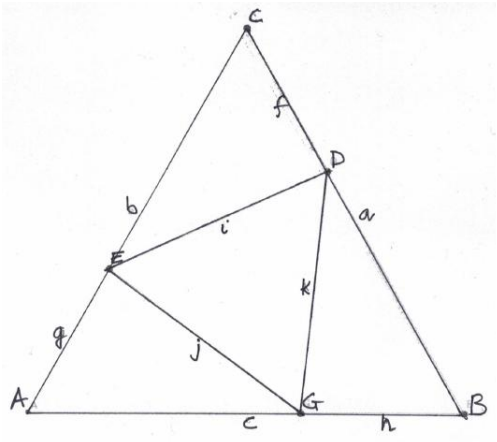

Figure 1: Two equilateral triangle

Construct triangle EDG inside triangle ABC.

In triangle EDG, Obtain points I, j and k in such a way EI =ID, EJ=JG, DK=KG.

Also, draw line passing through vertex C and a point I intersects at line AB at point M, similarly, draw line passing through vertex B and point k which interacts line AC at point **K.** Similarly, also draw line passing through the vertex A and point j which intersects line CD at L. (Fig. 2).

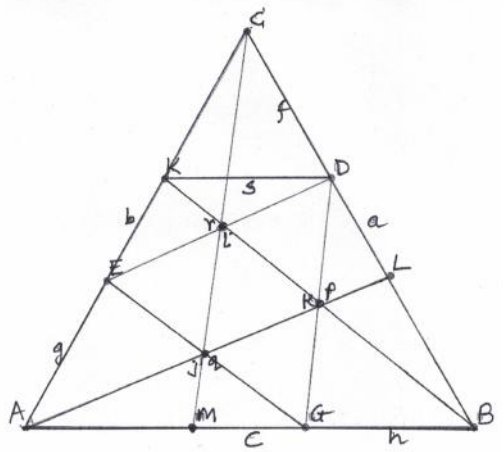

Figure 2: Golden sections and vertices

Construct hexagon KDLGMEK (Fig. 3) for which

$$\frac{KD}{KE} = \frac{EM}{MG} = \frac{GL}{LD} = \phi .$$

Proof for $\frac{KD}{KE} = \phi$:

By applying cosine rule for triangle CED,

$$ED^2 = CE^2 + CD^2 - 2CE \times CD \times \cos 60^\circ \tag{3}$$

Also, it can be seen from triangle ABC, $\frac{CE}{CD} = \varphi \Rightarrow CE = \varphi CD; CD = \frac{CD}{\varphi}$

Substituting above value into equation (3)

$$ED^2 = \left(\varphi CD\right)^2 + CD^2 - 2\varphi CD \times CD \cos 60^\circ$$

$$ED^2 = \varphi^2 CD^2 + CD^2 - 2\varphi CD \times CD\left(\frac{1}{2}\right)$$

$$ED^2 = CD^2\left(\varphi^2 - \varphi + 1\right)$$

$$ED = \sqrt{CD^2\left(\varphi^2 - \varphi + 1\right)}$$

$$ED = CD\sqrt{\left(\varphi^2 - \varphi + 1\right)} \tag{4}$$

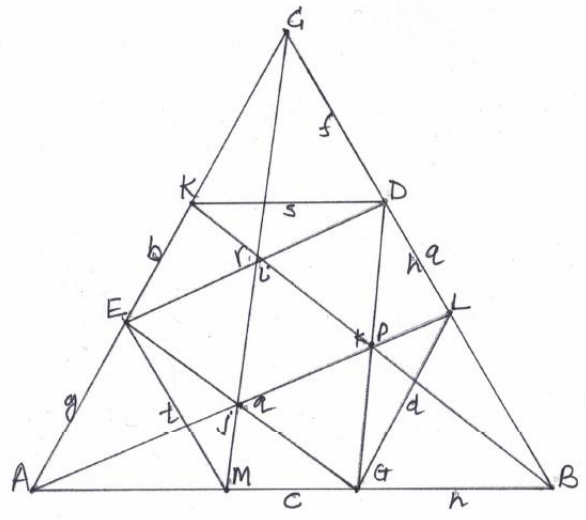

Figure 3: Golden hexagon

Here, Take, CD = KD such as, triangle CKD gives another equilateral triangle for which angle CKD is 60 degree. Since KD is horizontal parallel line to line AB, angle DKE is 120 degree.

Now, applying sine rule for the triangle KDE, knowing length ED as in equation (4), and the angle DKE,

$$\frac{ED}{\sin K} = \frac{KD}{\sin E} = \frac{EK}{\sin D} \tag{5}$$

$$\frac{CD\sqrt{\left(\varphi^2 - \varphi + 1\right)}}{\sin 120} = \frac{KD}{\sin E} = \frac{EK}{\sin D}; \tag{6}$$

Knowing $KD = CD$, substituting in equation (6),

$$\frac{CD\sqrt{\left(\varphi^2 - \varphi + 1\right)}}{\sin 120} = \frac{CD}{\sin E}$$

$$\sin E = \frac{CD \times \sin 120}{CD\sqrt{\left(\varphi^2 - \varphi + 1\right)}} \tag{7}$$

$$\sin E = \frac{\sin 120}{\sqrt{\left(\varphi^2 - \varphi + 1\right)}}$$

$$E = \sin^{-1} \frac{\sin 120}{\sqrt{\left(\varphi^2 - \varphi + 1\right)}} \tag{8}$$

$$D = 180 - E - K$$

$$D = 180 - \sin^{-1} \frac{\sin 120}{\sqrt{\left(\varphi^2 - \varphi + 1\right)}} - 120 \tag{9}$$

From equation (6),

$$\frac{KD}{EK} = \frac{\sin E}{\sin D} =; \frac{\sin\left(\sin^{-1} \frac{\sin 120}{\sqrt{\left(\varphi^2 - \varphi + 1\right)}}\right)}{\sin\left(180 - \sin^{-1} \frac{\sin 120}{\sqrt{\left(\varphi^2 - \varphi + 1\right)}} - 120\right)} = \varphi$$

Hence given proof for, $\frac{KD}{EK} = \varphi$.

Also, it can be observed from the triangle, KC = CD;

KC=CD;KE=EC-KC

$$\frac{\text{EC}}{\text{CD}} = \varphi; EC = \varphi CD$$

KE=φCD-CD

KE=CD$(\varphi$-1$)$

$$\frac{CD}{KE} = \frac{1}{(\varphi - 1)} = \frac{KC}{KE} = \varphi$$

Conclusion

In this article, golden sections, equilateral triangle and golden hexagon are related with each other. The final geometry gives golden hexagon with irregular adjacent sides. This paper gives fundamental design and construction of golden hexagon. The geometrical proof has been given for the ratio of the two adjacent sides of the golden hexagon which gives the value φ. The

significance of the work: there are many interesting and infinite mathematical relationships and oddities in Phi φ that can be explored in more depth.

Acknowledgement

Author would like to express a sincere thanks and gratitude to Navrachana University and especially to Prof. Abir Mullick, Provost, NUV for giving the support, encouragement and an opportunity to carry out this work. This work is an outcome of the interdisciplinary course Maths and Pattern.

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Mainstream and Shadow Education: Contestations in Form and Function of School

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Abstract

The trajectory of development of the institution of school for imparting education demands an analysis of the challenges it faces and its response to the challenges. The impact of the emergence and spread of the private coaching industry is so extensive that its existence is recognized as shadow education. Mainstream education comprises institution of school among other formal institutions of education. The response of schools to the private coaching industry demonstrates that there has been a play with form and function of schools. Currently, there is an amalgamation of the shadow education and mainstream education in the form of Concept Schools. An analysis of the responses of school- the mainstream education- to the challenge of shadow education- the private coaching industry raises a significant question on the primary function of schools and the trajectory that value education will follow.

Keywords

Form of school, function of school, mainstream education, shadow education system, exam oriented learning, value education

Introduction

The trajectory of development of the institution of school for imparting education offers an insight into the way institutions are established and the metamorphosis they undergo in the face of changing societal challenges. School is an institution which caters to the twelve years of education for children in the age group of six to eighteen years. The contemporary school and its challenges can be examined employing Sullivan's principle (1896) 'Form ever follows function' from architecture. The principle indicates that the form of an object or a building is

based on its intended function. Responding to the challenges for shape of a building of the industrial society Sullivan stated,

"Whether it is the sweeping eagle in his flight, or the open apple-blossom, the toiling work-horse, the blithe swan, the branching oak, the winding stream at its base, the drifting clouds, over all the coursing sun, form ever follows function, and this is the law. Where function does not change, form does not change. The granite rocks, the ever-brooding hills, remain for ages; the lightning lives, comes into shape, and dies, in a twinkling.

It is the pervading law of all things organic and inorganic, of all things physical and metaphysical, of all things human and all things superhuman, of all true manifestations of the head, of the heart, of the soul, that the life is recognizable in its expression, that form ever follows function. This is the law." (Sullivan, 1896)

This establishes the supremacy of function. Not restricted to the building alone, form and function principle provides an appropriate handle to grasp the metamorphosis of school and school education.

Question of Priority in Functions of School

The root of the functions of school lies in the evolution of society and its needs. As the nomadic mode of life gave way to life in settlement and as the society evolved from simple to complex, transmission and preservation of knowledge became necessary. The seeds of school were sown here. The family fulfilled this responsibility in simple society. With the society becoming complex, the inadequacy of family to fulfil this role was felt and hence separate institutions for education- schools- were established. The broader goals of education served as the framework for function of schools. These broader goals are: preparation for livelihood; getting equipped to fulfil roles and responsibility within family, society and the country; and becoming a 'better person'- the connotation of which is contextually drawn. An articulation of the goals of education in the post independence phase provides a framework within which education is designed and implemented in India. Based on the recommendations of Education and National Development (1964), National Policy on Education (1968) recommended a radical reconstruction of education system for economic development, cultural development, for national integration and for realising socialist pattern of society. The goal of nurturing 'better person' is articulated as 'the education system must produce young men and women of character and ability committed to national service and

development.' Following the policy framework, the school, as a significant institution of education, employed various mechanisms to fulfil its functions through curriculum and its spatial and temporal arrangements. The challenge for the schools has been: can it fulfil all the three functions or only some? If it cannot fulfil all its functions then will there be another form to fulfil the functions that schools cannot fulfil? If other forms are established then what will be the nature of the forms?

The contemporary schools and society faces the challenge of prioritising among the three goals of education as these become fiercely competitive. The goal of preparing for livelihood assumes priority. The paradigm of scarcity dominates field of education in India making elimination of students at various stages necessary. Coupled with this is the perceived hierarchy of 'jobs' in society, which leads to fierce competition for admission to a few preferred institutions of professional education. The function of schools thus becomes preparing learners for this competition, ordinarily known as examination oriented schooling. At the same time the other two goals of education- getting equipped to fulfil roles and responsibility within family, society and the country, and becoming a 'better person' become a secondary focus. Two decades later, National Policy on Education, 1986, reiterates the significance of the other two goals, "The growing concern over the erosion of essential values and an increasing cynicism in society has brought to focus the need for readjustments in the curriculum in order to make education a forceful tool for the cultivation of social and moral values". Value education thus is recognized as an important function of schools.

Schools face a challenge in prioritising between examination orientated education and value education. These two contemporary needs of society have influenced the form and function of schools. In doing this, it has thrown two specific challenges. First, is the function of schools to prepare learners for the competition for selection in courses of professional education? Secondly, whose responsibility will value education be? Both these challenges have given rise to new institutions and thereby raised questions of function for the institution of school.

Rise of Shadow Academic Institution and its Impact on Functions of School

The response to the first challenge has been the rise of shadow institutions of education variously known as shadow system of education or the parallel education or the tuition classes. Mainstream educational institutions refer to those educational institutions which are

recognized and certified by state and are affiliated to boards of education such as State Boards, Central Board of Secondary Education, Boards, Central Board of Secondary Education, International Baccalaureate, IGSC and ICSE. Shadow educational institutions on the other hand do not require recognition and certification by state or Boards of education. Bray (2007) has explained the appropriateness of the term shadow education: it is a shadow because a mainstream education exists, its features are less distinct than the mainstream education and it changes as the mainstream education changes. The emergence of shadow system of education has been observed in the education systems of the world with a strong presence in Asia. Bray and Lykins (2012) estimated that while shadow education grew at over 15 per cent per year in general, it was worth $255 in Hong Kong and China in 2011 and that Japanese parent spend $12 billion towards private tutoring. Though the phenomenon of private coaching classes in India has a large scale presence, the extent of its presence and impact is different in each state. Sujatha (2014) stated that among the four states sampled with varied socio-economic and political context, a strong presence of private coaching classes was observed in Kerala and a low presence in Andhra Pradesh. The relationship between school and the shadow institution of education has manifested the tensions between form and function in a distinct and interesting way. Three distinct phases of response of schools to these tensions can be identified as criticism; tacit acceptance and recognition; and amalgamation.

In phase one, the schools have been critical of the shadow institution. Schools therefore have focused on the supremacy of their institution by stating that their function is the overall development of the learner while the shadow institutions have limited function of preparing learners for examinations. To emphasize and demonstrate this, there has been a spread of co-curricular activities in schools. The shadow institutions, on the other hand, have been firm and unaffected by schools. The response of schools has further helped to clarify the function of shadow institutions, that it is seriously focused on academics and preparation for examination. This helps the prime stakeholder of school- learner and the parent – to choose and prioritise their attention and time between the two institutions. The spatial and temporal arrangement: the space of the school and the time table in school remained unaffected.

The relationship between schools and shadow educational institutions evolved to a second phase wherein there was a tacit acceptance and recognition by schools of the existence of shadow educational institutions. It was also acknowledged that their stakeholders- the

learners- participated in the shadow institutions. The school's response in this phase was that of accommodation. Schools' schedules attempted tacitly to accommodate the schedules of the shadow institutions. This also eased the burden on learners as they divided their study time between school and the shadow institutions. Till this stage, the schools retained their form but their function was shared by the shadow education. The spatial arrangements were unaffected but the temporal arrangement saw covert changes.

In phase three, the shadow institutions evolved to take the form of a school as there was an amalgamation of form and function of school and shadow education within the school. The state of Andhra Pradesh saw a transformation of private tutorial and coaching centres into private unaided schools which resulted in a low demand for shadow education (Sujatha, 2014). Another transformation was in the form of a Concept School. A Concept School is an educational institution which follows the function of preparation for examination, especially the board examinations. It, at the same time, has the form of a school as it is recognized as a school by state education authority. Learners and parents were relieved by this accommodation between the form and function. Though Concept Schools were established for class XI and XII and primarily aimed at preparing the learners for admission to professional courses, some mainstream schools have introduced these from class IX. Thus now form and function of school is retained and a part of its responsibility is entrusted to shadow education.

Rise of Shadow Co-Academic Institution and its Impact on Functions of School

The second tension between form and function of schools as an institution has been the function of value education. Though value education has been variously termed as moral education and lately peace education, in this paper the term value education is preferred as stakeholder-learners and parents- popularly use this term.

Value education is a contested zone between the institution of family and the institution of school. The contestations occur for two reasons. First, there is an inadequacy in each institution to cater to value education as the society becomes complex. Secondly, society also faces the problem of prioritising between valuing skilled learners with capability to earn livelihood and contribute to the economy or valuing learners with capability to live well as a citizen in society. The contestations are intensified as each of this institution expects the other to cater to it primarily. The schools endeavour to create a balancing act by offering to

learners a combination of curricular and co- curricular learning experiences. The shadow institutions as of now do not offer co-curricular learning experiences. With the accommodation of shadow systems of education within the school, the function of academics is a shared responsibility. Value education then forms a focus for the school. This function too is fraught with various challenges for schools: Will this function of schools to prepare better citizens for family, society and country through value education be taken over by other forms of institutions? Is there a shadow education system for value education? Will there be tuition classes for value education? If these alternative institutions develop, what will be the form and function of schools? There are two forms of responses to this.

First, some schools are established with a strong focus on value education which also becomes its defining characteristic. These schools have the philosophy of its founder or patron as the overall framework for the function of schools. The founders of school claim value education as their preferred function which is combined with the academic function. The stakeholders however do not always share this preferred function. Thapan (1991) has observed that the case of Rishi Valley School, which follows J Krishnamurthy's philosophy, indicates that there is a conflict between the value focus and the secular function of the school. In the absence of the founder or a strong leadership, the secular function takes precedence.

Another response is by various voluntary religious and community organizations which have adopted the function of value education for citizens of various age groups. These institutions invite voluntary membership for the learners as well as for the teachers. The curriculum is developed informally based largely on the major discourse of their patron leader and is continuously evolving. Currently, the voluntary nature of these institutions does not create a conflict with the form and function of school. At the same time, it does offer an alternative to the schools for the function of value education. Will the function of value education take the route of a concept school is a question which remains to be explored.

Conclusion

The emergence of shadow education system is an indicator of the extent to which the institution of school has been able to respond to the challenge of its form and function. In the case of academics, the amalgamation of shadow education within the mainstream education has given rise to Concept School. This amalgamation may pose more challenges in future:

will the shadow education become mainstream education? The challenge of the function of value education is yet to take a definite form. If value education is taken over by shadow education then the challenge for schools will be to search for a function for itself.

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Volume - 1

Issue - 2

Porous Pavement: Design and Cost Evaluation

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Abstract

This study is a representation of the survey and experimental works carried out for the design of Porous Pavement as a Flexible Pavement. Porous Pavement is a new concept and does not find its application much in developing countries like India so the researchers are seeking opportunities to work on this new concept. Application of porous pavement will allow storm water to infiltrate into the ground thus reducing the problem of water accumulation in the areas. For this study, Siddharth Bungalows at Sama-Savli road of Vadodara has been selected for the Traffic Volume study and Road Inventory survey. The above residential road experiences a great threat of storm water accumulation during every monsoon. For this, rainfall data of different day, month is collected. Another important part is the traffic volume count which will help determining the low traffic volume load. The thickness of each component layers can be determined by collecting the soil of the location and determining its CBR value. The material selected is single sized aggregates of sizes 20mm, 10mm and 6mm and various laboratory tests are performed on these to determine their engineering properties. Here, Bitumen is replaced by low viscous and locally available material Tar.

Keywords

Porous Pavement, Traffic Volume, Flexible Pavement, single sized aggregate, Drainage

Introduction

Porous pavement involves use of materials which have voids inside it and will help in infiltration of water thus allowing it store in the storage layer beneath and finding its use for irrigation purpose or for rain water harvesting. It's application in the areas where there is a problem of storm water accumulation will help environment by reducing the storm water volume, storing the water for other uses and lowering the temperature of road especially in summers. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through pervious concrete are around 480 in./hr (0.34 cm/s, which is 5 gal/ft²/ min or 200 L/m²/min), although they can be much higher. Due to the increased void

ratio, water is conveyed through the surface and allowed to infiltrate, and evaporate, whereas conventional surfaces will not do so. A porous pavement surface therefore plays an active part in the hydrological cycle as rainfall is conveyed back to ground in the form of infiltrating water and run-off.

Study Area

Vadodara, also known as cultural capital of Gujarat, is the third largest city in western Indian states. The area selected for the study is Siddharth Bungalows near Sama-Savli road, Vadodara. It is one of the waterlogged areas in Vadodara. The rainfall data are collected from the Vadodara Irrigation Department. The Road inventory survey and Traffic volume survey are carried out here.[4]

Drainage Considerations

Drainage under the component layers of pavement can be provided to pass the storm water which has been infiltrated from the surface. These drains can help the storm water to flow directly into the rivers or streams or it can be used in the fields too.

Material Selection

For the selection of Porous material, single sized aggregate of size 6mm, 10mm and 20mm are selected. A mould is made from the single sized aggregate and locally available Tar by using 6mm, 10 mm and 2 mm aggregate with 5% tar and mixing it thoroughly with the aggregate sample. It is observed that 10mm and 20mm size aggregate mould is collapsed while in 6mm sized aggregates, it remains stable and does not collapsed and 6mm single sized aggregate with 5% tar is selected as a porous material for the study.

Data Collection and Analysis

For designing the Porous Pavement, the data collection part includes soaked CBR of soil sub grade, Road inventory survey, Traffic volume survey various laboratory tests conducted on single-sized aggregates and some important tests of Bitumen which are conducted on Tar.[7]

Standard Proctor Test		CBR value(Soak) %
MDD	OMC	
1.858	11.9	10.8

Table 1: CBR value of soil sub-grade

Test	Test Method	Result		
		6 mm	10 mm	20 mm
Aggregate Impact Value	IS: 2386 (Part-4)	6.06	9.375	3.55
Aggregate Crushing Value	IS:2386 (Part-4)	10.16	8.25	6.11
Specific Gravity	IS: 2386 (Part-3)	2.83	2.5	0.34
Water Absoption	IS: 2386 (Part-3)	3.37	0	94

Table 2: Tests on single sized Aggregates

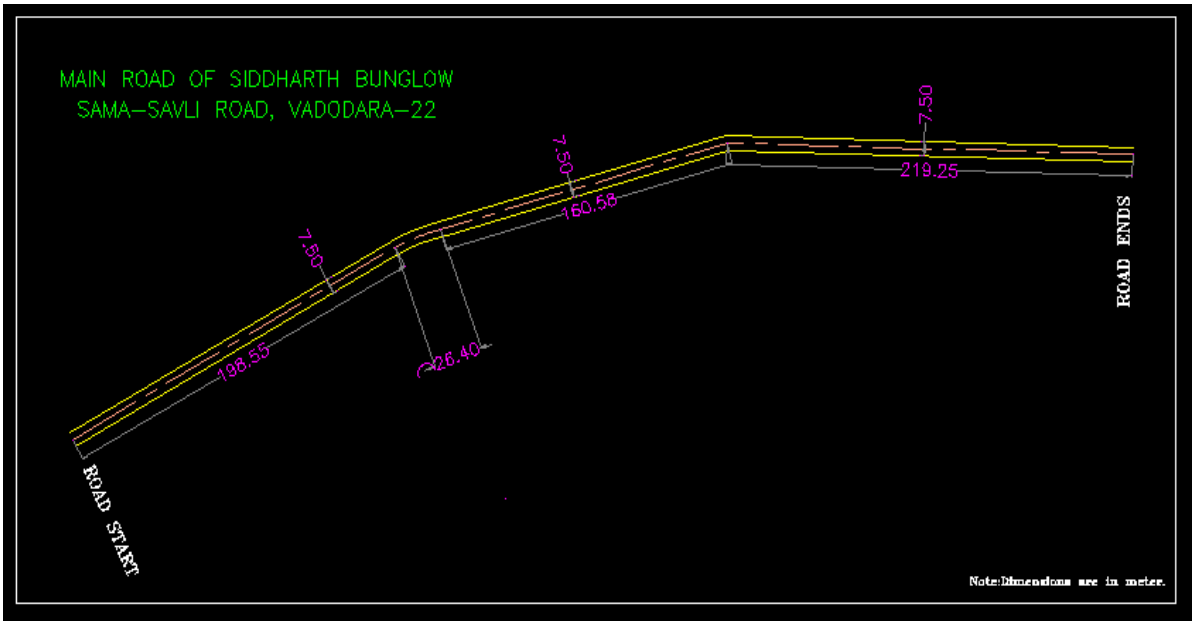

Figure 1: Road Inventory survey

Property	Requirement	Result
Penetration 25°C	IS: 1203	8 mm
Softening Point °C	IS: 1205	95.1
Ductility	IS: 1208	2 cm
Marshall Stability	MORTH	5.41 kN
Flow Value	MORTH	5
Melting Point	-	53°C

Table 3: Tests on Tar

Week Days (IN Direction)								
		2-Wheeler	4-Wheeler	3-Wheeler	LCV/ HCV	Bus/ Truck	Cycle	Pedestrian
Peak Hours	Morning	46.375	18.25	15	4.5	0.75	5.775	118
	Evening	75.75	29.25	15.5	6	0.75	6.25	114
Off-Peak Hours	Morning	70.75	31.5	20	7.5	1.5	9	35
	Evening	76.25	35	6	3	0	3.5	57

Week End (IN Direction)								
		2-Wheeler	4-Wheeler	3-Wheeler	LCV/ HCV	Bus/ Truck	Cycle	Pedestrian
Peak Hours	Morning	50.75	23.75	17	5.25	7.5	5.875	129
	Evening	66.75	38.5	11.5	2.625	0.75	0.75	89
Off-Peak Hours	Morning	39.75	43	19	2.25	1.5	3.75	42
	Evening	73	38	13	1.5	0	3.25	54

Week Days (OUT Direction)								
		2-Wheeler	4-Wheeler	3-Wheeler	LCV/ HCV	Bus/ Truck	Cycle	Pedestrian
Peak Hours	Morning	79.625	47.25	9	6.375	1.5	2.75	60
	Evening	57.25	25.75	27.75	3.75	0	5.25	149
Off-Peak Hours	Morning	51.25	23.5	18	21	6.75	6.75	35
	Evening	70.5	23.5	7	4.5	2.75	2.75	42

Week End (OUT Direction)								
		2-Wheeler	4-Wheeler	3-Wheeler	LCV/ HCV	Bus/Truck	Cycle	Pedestrian
Peak Hours	Morning	74.37	42	17.5	3.75	6.75	4	76
	Evening	71.37	35.25	10	3.75	1	34.5	141
Off-Peak Hours	Morning	52.25	46	13.5	3	0	7	126
	Evening	49.75	26	14	0	0.75	6	57

Table 4: Traffic Volume Survey

Monthly Summary					
Months	2009	2010	2011	2012	2013
June	4	16	33	10	60
July	67	31	134	115	119
August	36	34	70	162	72
September	5	83	39	5	218
October	18	0	2	0	32
Total (mm)	130	164	278	292	501

Table 5: Rainfall Data

Design of Porous Pavement using IRC 37[6]

Data:-

i. Initial traffic in the year of completion of construction=834 CV/Day
ii. Traffic growth rate per annum=7.5 per cent
iii. Design life=10 years
iv. Vehicle damage factor=3.5
v. Design CBR of sub grade soil=10%
vi. Annual growth rate of commercial vehicles=0.075

Calculations:-

(i)Distribution factor (para 3.3.5) =0.75

(ii)Cumulative number of standard axles to be catered for in the design

N= $[(365x \{(1+0.075)^{10}-1\})/0.075]x834x0.75x3.5$

=11.3 msa

(iii)Total pavement thickness for CBR 10%and traffic 11.3 msa=540mm

(From figure: 2)

(iv)Pavement composition interpolated from Plate-2, CBR 10%

(a) Bituminous surfacing = 40 mm BC +50 mm DBM

(b)Road base =250 mm

(c)Sub-base =200 mm

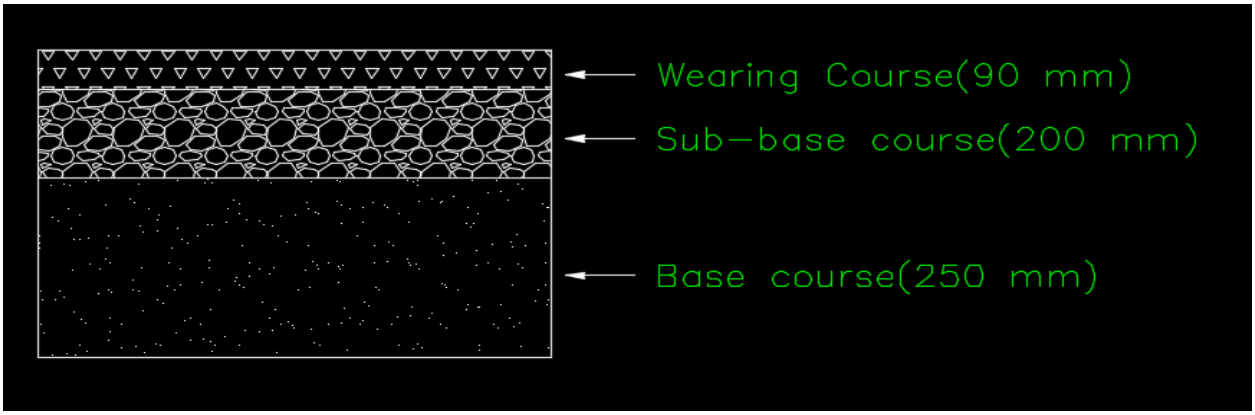

Figure 2: Pavement Thickness

Cost Evaluation

Items	Dimensions			Rates	Result
	L (m)	B (m)	H (m)		
Base course	1	7.5	0.25	107 Rs/m^2	201 Rs/m^2
Granular Sub-base course	1	7.5	0.20	700 Rs/m^3	1050 Rs/m^3
Wearing Course	1	7.5	0.09	2661 Rs/m^3	1796 Rs/m^3
Total Rate per km					3047175 Rs.

Table6: Cost Evaluation of Porous Pavement

Items	Dimensions			Rates	Result
	L (m)	B (m)	H (m)		
Base course	1	7.5	0.25	107 Rs/m^2	201 Rs/m^2
Granular Sub-base course	1	7.5	0.20	700 Rs/m^3	1050 Rs/m^3
Wearing Course	1	7.5	0.09	1456 Rs/m^3	982.20Rs/m^3
Total Rate per km					2233000 Rs.

Table 7: Cost Evaluation of Flexible Pavement

Conclusion

From the survey and laboratory work carried out, it can be concluded that the rainfall data obtained shows the area receives heavy rainfall during every monsoon. The width of the road obtained after Road Inventory survey is 7.5 m. The result of the Traffic volume survey shows PCU/hr which is low and can be preferred for constructing porous pavement on it. The focus of the research was to design Porous Pavement as Flexible Pavement. For that, the wearing course material Bitumen was replaced by Tar which is low viscous and locally and easily available. Single-sized aggregates of sizes 20mm, 10mm and 6mm were used and various laboratory tests were conducted to determine their engineering properties. Then major tests of

Bitumen were conducted on Tar. Marshall Stability test was conducted on the combination of aggregates and Tar and their feasibility as a wearing course was determined. As per IS, 6mm sized aggregates satisfies most of the test value range. From the Bitumen tests to be conducted on Tar, the values does not satisfies the IS range but it was observed that Softening point of Tar is more than Bitumen.

Future Scope

As observed from the laboratory tests and design, it is suggested that the samples should be tested for Stripping Value for further knowledge of their behavior. The samples should also be tested with the use of stone dust and other sizes of aggregates for accurate results. The economic benefits attained by using Porous Pavement design can also be determined

Acknowledgement

We would like to express our gratitude towards our guide Ms. Vaidehi Jain who gave us opportunity to focus on the project in one of the wide field by guiding us in various scenario during project and gave numerous consultations. We are thankful to our Head of the Department, Navrachana University, Dr. Bhairav Thakkar for encouraging and sharing great knowledge. We are grateful to Mr. Nitin Darji who helped us during the project span, overcoming some difficulties and helping us in many ways. In addition, we would like to thank Mr. Pradip Chauhan (Geo-test House, Vadodara), Mr. Amit Rana (Geo-test House, Vadodara) and Mr. Santosh Zunjar (Independent Consultants and Technocrates, Vadodara) for allowing and helping us to perform laboratory tests in their premises. Lastly, we would like to show the deepest gratefulness towards our Parents for believing in us and greatly motivating us in their best possible ways.

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Mathematics Teaching - Balancing Abstract Verses Concrete

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My forms are not abstractions of things in the real world. They're also not symbols. I would say that my job is to invent these forms and to put them together in a way that keeps your interest, to give the forms a quirky identity so you can engage with them, so you realize there's an inner intelligence or logic.

Caio Fonseca (American Painter)

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Abstract

Mathematics educators all over world find it difficult to the engage learners towards the effective learning of mathematical concepts. Interiorizing these abstract ideas without referring to anything real or tangible, require thinking and visualizing skills at higher cognitive level. To overcome this difficulty, real life examples were made mandatory for mathematical teaching, which helped in improving the understanding level to some extent. However, associating all mathematical concepts to things which the students can see or know was not only difficult but also failed to develop the skills required to generalize these concepts after decontextualizing them from these base cases. The present work is based upon a survey of the methods adopted in mathematics education at various levels and also discusses the effectiveness of teaching Linear algebra to undergraduate students in an abstract way with very limited but appropriate usage of concrete examples**.**

Keywords

Abstraction, Generalization, Decontextualisation

Introduction

Teaching mathematics at all levels of education remains challenging for instructors. On one hand, it is highly satisfying to teach a handful of motivated students who enjoy exploring the ultimate truth in the supreme beauty of mathematics, while on the other, it is frustrating to see most students struggling to understand the concepts and apply them to the methods employed for finding solutions to contextualized problems.

Various studies[1-3] over the past several decades have attributed the '*mathematics phobia*' among young learners to the '*abstractness in mathematics*'. It is interesting to see that largely students believe that they learn mathematics as a part of the curriculum which has no relevance to anything concrete in real life situations. Everyday words with meaning in relation to other mathematical terms (without their actual meanings) are used, say for example '*zero*' which means '*nothing*' in real world, is understood as the '*additive identity*', representing different things in different mathematical structures. In Vector algebra it represents a vector with zero magnitude and no direction, whereas in quotient group of integers modulo n (n is an integer), the number n and all its multiples are equivalent to zero. Thus in the quotient group of integers modulo 2, all even numbers are identified with the zero, a concept very different from the meaning of *zero* used elsewhere.

Owing to the abstractness in mathematics and mathematical learning, serious attempts are made by instructors to make mathematics meaningful by linking the ideas to concrete materials or find their real life applications. In the last few decades, teaching methods involving concrete examples were emphasized to such an extent that the journal '*Mathematics Teacher*' (November 1993) devoted the entire issue to this aspect and the editorial board challenged teachers to find at least one example or a link for each topic in mathematics they taught with a real life situation. However, an important research[4] in this area has shown that relating concrete examples or tangible things to abstract mathematical ideas failed to enhance the learning among the students substantially. This can be understood if we take the example of teaching the concept of fractions to elementary school students. Teachers conventionally give example of pieces of pizza or chalk *etc.* to link the concept with real life objects around them. Students at this level are already familiar with counting whole numbers. Although the number system was introduced to them with concrete examples of objects such as apples or counting fingers etc., over the years they have learnt to see, say, '5' as a number detaching it from these examples. They know that 3 can be subtracted from 5 but it is not possible to take away 3 oranges from 5 apples. Thus, subtraction becomes an object of thought for them and the operation is performed at an upper cognitive level without referring to any particular example. Skemp[8] noted that this was the unique ability of human beings to isolate concepts from any of the examples giving rise to them. However, it was seen that this ability to isolate the concept from the base context took a couple of years after learning the concepts. Thus, a similar approach of decontextualizing mathematical operations on fractions fails to reduce the complexity of the problems, as students neither see fractions

as pieces of pizzas always nor do they realize them as numbers when they operate upon them. Thus a child identifies *one sixth* of a pizza as *one piece* of pizza without referring to the whole pizza at all. Consequently, two pieces (one sixth each) of a pizza will not be seen as one third of the pizza by him. With a heavy emphasis on computational methods in elementary classes, students learn to manipulate problems involving fractions, but to convert the concept into an object of thought appears difficult.

Approaches in Mathematics education

Mathematics educators are often blinded with their assumption that generalization of a concept is a trivial process and it comes naturally to the learners. Some believe that mathematics should be taught as concrete $\longrightarrow$ abstract, which means starting with real world manipulative to understand the underlying principal first. The concept of differentiation at undergraduate level is introduced with a whole lot of examples say, change in velocity, growth of bacteria and economic growth, etc. followed by the classical definition of derivatives. Another approach of teaching mathematics is from abstract $\longrightarrow$ concrete. In fact most of the mathematics at the middle school and high school level is taught with the *abstract first* approach. For example, polynomials are taught without referring to their applicability to anything in the real world. Interestingly, polynomials are considered to be the building blocks of all sciences because of being simple curves which can be easily manipulated, but capable of approximating complicated curves associated with all changes in nature such as weather, path of planets, mechanical forces, chemical and biological processes, etc. But, either the educators are unaware of the importance of polynomials in the study of science and technology at advanced levels or fail to communicate their importance to the students restricting themselves to the prescribed syllabus. Hence, students at high school level learn polynomials purely as symbolic expressions with the techniques of finding roots and factors without knowing about the significance of the concepts.

It was observed that both of the aforesaid pedagogical approaches have limitations as far as learning is concerned. Students learning with *concrete first* approach remain grounded towards the examples discussed and are not able to generalize the concepts for application to a wider variety of mathematical structures. On the other hand those who learn from *abstract first* approach lose interest because of the abstractness associated with mathematics and its education. Nevertheless, in both of these approaches of teaching-learning mathematics, the

concept of abstractness is understood as something which is not related to the real world. But as we see in the next section, abstractness in mathematics is also associated to a general idea perceived from a collection of apparently different concepts.

What is abstractness in mathematics?

In order to understand the 'abstractness' ascribed to mathematics we need to first understand the word '*abstract*'. According to the Webster Dictionary (1977) we have:

***Abstract (adj.)*:** Apart from concrete; general as opposed to particular; expressed without reference to particular examples (e.g. numbers).
***Abstract (verb)*:** To consider apart from particular instances; to form a general notion of.

It is interesting to see that although abstractness of mathematics is understood as it's disconnectedness from anything concrete in real life, but from the definitions it appears that '*apartness from concrete*' and '*generality*' are the two aspects to which it is attached. Mitchelmore et al.[5-7] have classified mathematical ideas into two categories, *abstract-apart* and *abstract-general.* The ideas which are *abstract apart* are actually disconnected from any particular context and hence need not be applicable to real life situation. On the other hand *abstract general* ideas are those ideas which arise in the process of abstracting a common property from a variety of disconnected base contexts, after recognizing some similarity between them. For example, before teaching the methods of solving linear equations symbolically, teachers give a series of situations in real life which give rise to such equations. These *abstract general* ideas help the learner to build up new relations at higher level of abstraction in terms of already familiar base contexts and allow them to develop ideas to be applied to relatively newer situations. At this level of understanding the existing ideas become more general and hence more abstract.

Abstraction as a component of mathematics education

Thus, mathematical abstraction is more of a process than a product and it should be well integrated in mathematics education. If the focus of mathematics education is more on pattern recognition, which means finding similarities between apparently different structures, mathematics becomes more appealing to the students. They learn to develop relations and identify the set of rules applicable to equivalent systems. Contrarily, in most of the situations we see that mathematics education is imparted as transfer of *abstract apart* ideas without

going through the process of abstraction. Even though some students enhance their computational skills by mastering the rules to work upon the symbolic representations, but majority of them lose interest in mathematics thinking it to be all about boring calculations guided by meaningless set of rules. Algebra, one of the most important branches of mathematics is taught in a way which has very little to cater to the thought process of developing the algebraic expressions. As an example, learning the techniques of finding roots to complicated algebraic equations is given more importance than to understand the geometric interpretation and the behavior of the curves in the neighborhood of these roots. Only some students who are so called '*mathematically abled*' learn how to simplify algebraic expressions without thinking or knowing much about the implications of the methods involved. But, not much is gained in terms of mathematical insight because with the intervention of computers, computational skill is anyway a lost battle to the present day software available. Hence, learning mathematics necessarily requires developing the skill to think beyond the contexts along with the ability to visualize the geometry, recognize pattern or understand the deeper meaning associated with the concepts.

Limiting over-usage of concrete examples in mathematics education

Furthermore, there are conflicts regarding the usage of concrete examples by mathematics instructors. A very important finding of Kaminski[4] was that although these examples help in understanding the abstract mathematical ideas by relating them with things we know about, but keep us from the generation of newer ideas or application of the existing ones to novel situations. On the other hand, playing around with pure mathematical symbols makes the very essence of mathematics impregnable for the learner. In fact, a careful study of teaching methodologies revealed the fact that in mathematics education, there is a dichotomy in both the approaches. We have seen that in the last decade an enormous number of research papers have been published supporting either of the two approaches strongly. However, we tried to experiment with a different pedagogy for teaching mathematical concepts at undergraduate level, at Navrachana University, Vadodara, by introducing the abstract concepts directly without relating to anything concrete, in the introductory lectures. We observed that initially the students struggled to interiorize the concepts in the absence of examples which were easy to visualize, but gradually they learnt to cope with the abstractness of mathematics. In fact, as an extension of theoretical learning, they started relating the abstract mathematical ideas with things they could envisage. Also, as every brain perceives

things in a unique way, they were discussing a larger variety of situations which could be associated to the understanding of the concepts. It was like writing a story about an abstract piece of art work depending upon each one's own perception. We saw that the inhibitions were broken and everyone participated in the teaching-learning process which is very rare in a mathematics class. We tried to disengage mathematics learning with the idea of learning problem solving techniques alone. In fact, as instructors we ourselves learnt that getting wrong answer was the greatest fear among the learners, holding them back from trying out unknown methods to get the solution. We rated understanding, thinking and trying out newer approaches towards the solution higher than applying text book methods to come to the correct solution. Abstractness in mathematics no more appeared to be an obstacle in learning because it stimulated thinking and visualization, which is a natural play area of every young brain.

In order to explore more in this area, we studied the effect of establishing smooth bridges between both the approaches involving abstract and concrete, so that one can gently pass from one approach to the other depending upon the depth of the mathematical ideas and requirement of the learners. For example, an average engineer is required to know more about the applicability of the ideas to different situations rather than exploring deep into the logical flow and intricate mathematical steps used in proving them. However, the fast changing world today also requires them to understand the mathematical concepts to a greater depth, to cope with and contribute towards the continuously emerging technologies.

Teaching Linear Algebra in abstract way

We discuss the pedagogy involved in the teaching of Linear Algebra at undergraduate level in an abstract way in this section. Linear algebra is an advanced course in mathematics, introduced to all engineering undergraduate students, as it finds wide applications in every field of science and technology. However, students universally find it difficult to understand, presumably due to the transition from elementary to advanced mathematics. In most of the cases, the course is taught by the *concrete first* approach and builds upon the matrix theory, with which the students are already familiar. In this method of *concrete to abstract* teaching, the emphasis lies in dealing with the computations involving matrices, at the introductory level of the course. Now, the heart of the subject lies in interiorizing the variety of structures as vector spaces from the familiar two dimensional Euclidean plane R^2 to more abstract spaces such as the space of polynomials or the space of continuous functions. We observed

that the course starting with examples of R^2 and R^3 actually impedes the process of learning, keeping learners stuck with the calculations involved in proving the axioms and operating upon the matrices. The algorithms applicable to more abstract vector spaces are very different in nature to these operations and students taught with *concrete first* approach do not learn to visualize such situations and to apply appropriate algorithms to deal with them. For example, finding a basis for a vector space of continuous functions require very different algorithm than finding a basis for row vectors in $R^2$and R^3. Instead, we saw that by taking the *abstract first* approach and directly introducing the abstractness in the concept of vector spaces, a majority of students could conceptualize the ideas in the most general settings. The computational techniques were introduced as and when needed, focusing more on the identification of the deeper similarities between wide varieties of mathematical structures. This method of *abstract first* learning supported by suitable concrete examples provided an environment where the students were motivated to become independent learners and thinkers in a shorter span.

Conclusions

Our conclusion is that the abstract mathematical ideas should be appropriately balanced with concrete examples in mathematics education. Educators need to be aware of the extent of abstractness associated with individual topics within the courses and select concrete examples which are just enough to keep the learners engaged with the course. Although mathematics teaching cannot be completely devoid of concrete examples, but their usage should be limited to introductory levels only. Mathematics is abstract and sooner the students are exposed to the abstractness and the process of abstraction, greater is their achievement in terms of appreciating and understanding the concepts. There is an incessant list of examples where the ideas which were once considered highly abstract at some point, found applications in real world later. With appropriate choice of such examples students should be made aware of the fact that the beauty of mathematics and it's applicability are two different aspects but learning mathematics with all its abstractness widens the scope of finding applications, along with opening up the heart, mind and soul towards the subject, which is very essential for its effective learning.

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Direct Stiffness Method for a Curved Beam and Analysis of a Curved Beam Using SAP

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Abstract

Analysis of curved beam has been carried out for the unknown displacements and rotations subjected to horizontal and vertical loads and the moments at the ends. The concept of strain energy and Castigliano's theorem has been used to carry out the analysis. Two noded curved beam elements have 3 degrees of freedom (1) Rotation in out of plane direction, (2) Horizontal displacement and (3) Vertical displacement. Through energy concept, force - displacement relationship has been established for which 9 equations (3 for vertical displacements, 3 for rotations and 3 for horizontal displacements) are obtained by keeping node 1 fixed of the curved beam and other 9 equations (3 for vertical displacements, 3 for rotations and 3 for horizontal displacements) are obtained by keeping node 2 fixed. Remaining 18 equations are obtained from the equilibrium equations. These equations are used to form the element stiffness matrix. Final element stiffness matrix turns out to be of the size 6 x 6. Numerical example of the curved beam is analysed and for which the results are compared with the SAP2000.

Keywords

Direct Stiffness method, curved beams, Strain energy and Castigliano's Theorem

Introduction

Curved Beam is an elastic body whose geometric shape is formed by the motion in space of a plane figure called the cross section of the curved beam. The cross section of the curved beam is normal to the axis of the curve. Curved beam is a special case of an arch where the radius is constant. Moreover, this type of beam is used where a beam having long span without any intermediate support is to be provided. Few analytical formulations related to curved beam structural analysis has been done in the past. The derivation of generalized

stiffness matrix of a curved – beam element including normal - to – plane force components has been obtained by[1].

Based on the theory of virtual work and principle of thermal elasticity, exact solutions for in – plane displacements of curved beams with pinned – pinned ends are derived explicitly by [2]. A curved beam element for its application to traffic poles with assumptions curved traffic poles may vibrate when excited by the wind[3]. A 3 node curved beam element has been developed for static and dynamic analysis of curved poles. Shear deformation as well as rotary inertia effects are included. A stiffness matrix of order 12 x 12, for a curved beam element involving all forces together using Castigliano's theorem including the effects of transverse shear forces and tangential thrust given by[4].

When the structure is linear elastic and the deformations are caused by external forcesonly, the strain energy U, the displacement of structure in the direction of force is expressed by [5, 6]

$$\Delta_j = \frac{\partial U}{\partial P_j} \tag{1}$$

The Castigliano's theorem states that having the expressions for the strain energy invarious cases, avery simple method for calculating the displacements of point of an elastic body duringdeformation may be established. For example, in the case of simple tension

The strain energy of axially loaded bar is as given by

$$U = \frac{P^2 l}{2AE} \tag{2}$$

By taking the derivative of this expression with respect to P,

$$\frac{dU}{dP} = \frac{Pl}{AE} \tag{3}$$

The curved beam shown in the Fig.1 has the subtended angle β and radius = R force P_1 and P_2 are acting on node 1 and 2 respectively parallel to the direction of radius and Q_1 and Q_2 are the forces acting on node 1 and 2 respectively perpendicular to the direction of radius and M_1 and M_2 are the moments acting on node 1 and 2 respectively.

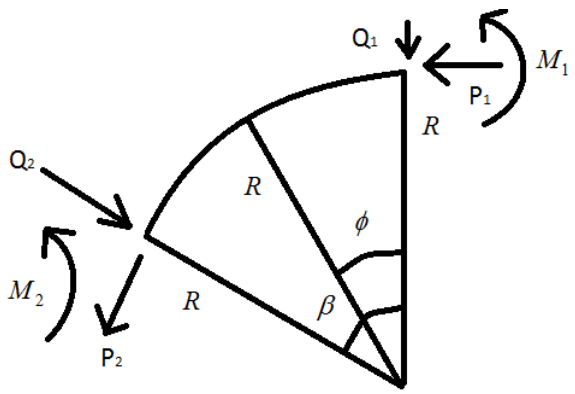

Figure 1: Curved beam section

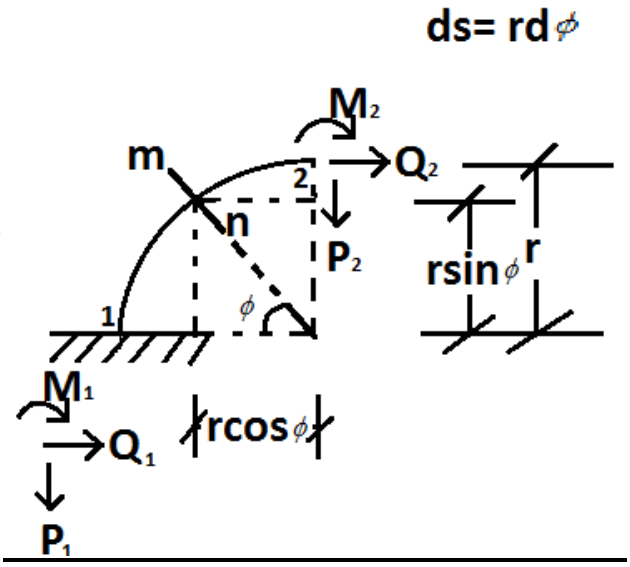

Figure 2: Curved beam – Node 1 is fixed

Derivation of Element Stiffness Matrix

The moment at section m – n from Fig.2,

$$M = -P_2 r\cos\phi - Q_2 r(1-\sin\phi) - M_2 \tag{4}$$

The directions of the forces are shown in Fig. 2. By applying Castigliano's theorem on above equation (4), for various cases, to obtain displacement as well as rotations for all possible cases, following equations are obtained. Displacements and rotations at the node 1 for a special case of curved beam when $b = \frac{p}{2}$ are given as below.

$$\delta_{VP} = \frac{P_2 r^3}{EI_Z}\left[\frac{\beta}{2} - \frac{\sin 2\beta}{4}\right], \quad \delta_{VQ} = \frac{P_2 r^3}{EI_Z}\left[-\cos\beta + 1 - \frac{\sin^2\beta}{2}\right], \quad \delta_{VM} = -\frac{M_2 r^2}{EI_Z}\left[\cos\beta - 1\right]$$

$$\delta_{HP} = \frac{P_2 r^3}{EI_Z}\left[-\cos\beta + 1 - \frac{\sin^2\beta}{2}\right], \quad \delta_{HQ} = \frac{Q_2 r^3}{EI_Z}\left[\frac{3\beta}{2} - 2sin\beta + \frac{\sin 2\beta}{4}\right]$$

$$\delta_{HM} = \frac{Q_2 r^2}{EI_Z}\left[\sin\beta - \beta\right], \quad \theta_P = \frac{P_2 r^2}{EI_Z}\left[\sin\beta\right], \quad \theta_Q = -\frac{Q_2 r^2}{EI_Z}\left[\beta - \sin\beta\right], \quad \theta_M = \frac{M_2 r}{EI_Z}\beta \tag{5}$$

The above equations can be written in combined form. By applying principle of superposition, the equations can be written in matrix form as follows.

$$\begin{pmatrix} v_2 \\ u_2 \\ \theta_2 \end{pmatrix} = \begin{pmatrix} \frac{\pi r^3}{4EI_Z} & \frac{r^3}{2EI_Z} & \frac{r^2}{EI_Z} \\ \frac{r^3}{2EI_Z} & \frac{r^3}{6EI_Z}\left[\frac{3\pi}{4}-2\right] & \frac{r^2}{EI_Z}\left[\frac{\pi}{2}-1\right] \\ \frac{r^2}{EI_z} & \frac{r^2}{EI_Z}\left[\frac{\pi}{2}-1\right] & -\frac{\pi r}{2EI_z} \end{pmatrix} \begin{pmatrix} P_2 \\ Q_2 \\ M_2 \end{pmatrix} \tag{6}$$

Equilibrium equations from the free body diagram shown in Fig. 2 when 1st is fixed and 2nd is free[7]

$$\begin{aligned} &\sum F_y = 0; Q_1 + Q_2 = 0; \boxed{Q_1 = -Q_2} \\ &\sum F_x = 0; P_1 + P_2 = 0; \boxed{P_1 = -P_2} \\ &\sum M_2 = 0; -M_2 - M_1 + P_1 r + Q_1 r = 0; \boxed{M_1 = -M_2 - P_2 r - Q_2 r} \end{aligned} \tag{7}$$

Remaining quantities of forces are found from the equilibrium equations (7) and will be used in writing element stiffness matrix later.

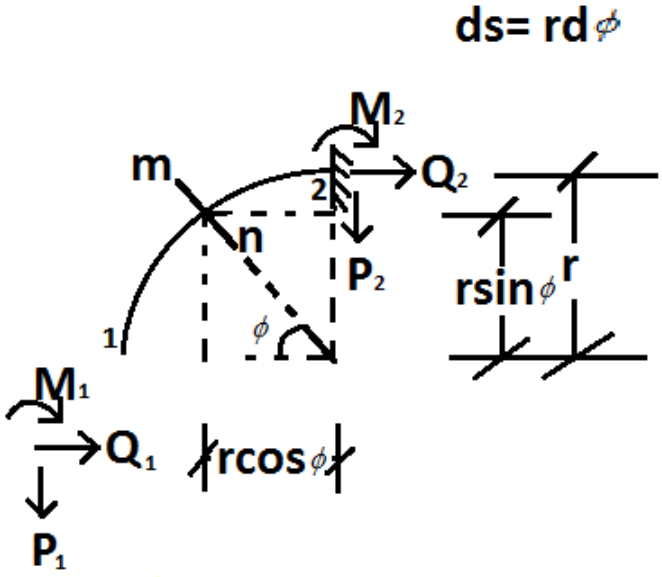

Figure 3: Curved beam – Node 2 is fixed

Moment at section m-n, referring to Fig. 3.

$$M = P_1 r(1-\cos\phi) + Q_1 \sin\phi - M_1 \tag{8}$$

By applying Castigliano's theorem on Equation (8), Displacement and rotation are obtained when node 2 is kept fixed and 1 is free.

$$\delta_{VP}=\frac{P_1 r^3}{EI_Z}\left[\frac{3\beta}{2}-2sin\beta+\frac{\sin 2\beta}{4}\right],\ \delta_{VQ}=\frac{Q_1 r^3}{EI_Z}\left[-\cos\beta+1-\frac{\sin^2\beta}{2}\right],\ \delta_{VM}=-\frac{M_1 r^2}{EI_Z}\left[\beta-\sin\beta\right]$$

$$\delta_{HP}=\frac{P_1 r^3}{EI_Z}\left[-\cos\beta+1-\frac{\sin^2\beta}{2}\right],\ \delta_{HP}=\frac{Q_1 r^3}{EI_Z}\left[\frac{\beta}{2}-\frac{\sin 2\beta}{4}\right],\ \delta_{HM}=\frac{M_1 r^2}{EI_Z}\left[\cos\beta-1\right]$$

$$\theta_{P1}=-\frac{P_1 r^2}{EI_Z}\left[\beta-\sin\beta\right],\ \theta_{Q1}=\frac{Q_1 r^2}{EI_Z}\left[\cos\beta-1\right],\ \theta_{M1}=\frac{M_1 r}{EI_Z}\beta \tag{9}$$

Equilibrium equations when 1st is free and 2nd is fixed are written as follows.

$$\sum F_y=0;Q_1+Q_2=0;\boxed{Q_2=-Q_1}$$
$$\sum F_x=0;P_1+P_2=0;\boxed{P_2=-P_1}$$
$$\sum M_2=0;-M_2-M_1+P_1 r+Q_1 r=0;\boxed{M_2=-M_1+P_1 r+Q_1 r} \tag{10}$$

Eq. (9) can be combined after applying superposition principle and written in matrix form as follows, when node of the curved beam 1 is kept free and 2 is fixed.

$$\begin{pmatrix} v_1 \\ u_1 \\ \theta_1 \end{pmatrix}=\begin{pmatrix} \frac{r^3}{EI_Z}\left[\frac{3\pi}{4}-2\right] & \frac{r^3}{2EI_Z} & -\frac{r^2}{EI_Z}\left[\frac{\pi}{2}-1\right] \\ \frac{r^3}{2EI_Z} & \frac{\pi r^3}{4EI_Z} & -\frac{r^2}{EI_Z} \\ -\frac{r^2}{EI_z}\left[\frac{\pi}{2}-1\right] & -\frac{r^2}{EI_Z} & \frac{\pi r}{2EI_z} \end{pmatrix}\begin{pmatrix} P_1 \\ Q_1 \\ M_1 \end{pmatrix} \tag{11}$$

By taking help of Eqs. (6), (7), (10), (11), the final element stiffness matrix is written as Eq. (12), which can later be used for solving numerical examples.

$$\begin{bmatrix} P_1 \\ Q_1 \\ M_1 \\ P_2 \\ Q_2 \\ M_2 \end{bmatrix} = \frac{r^4}{(EI_z)^2} \begin{bmatrix} \left[\frac{\pi^2}{8}-1\right] & \left[\frac{\pi}{4}-1\right] & \left[\frac{r}{8}\left[\pi^2-2\pi-4\right]\right] & -\left[\frac{\pi^2}{8}-1\right] & -\left[\frac{\pi}{4}-1\right] & -\frac{r}{8}\left[\pi^2-2\pi-4\right] \\ \left[\frac{\pi}{4}-1\right] & \left[\frac{\pi^2}{8}-1\right] & \frac{r}{2}\left[\pi-3\right] & -\left[\frac{\pi}{4}-1\right] & -\left[\frac{\pi^2}{8}-1\right] & -\frac{r}{2}\left[\pi-3\right] \\ \left[\frac{r}{8}\left[\pi^2-2\pi-4\right]\right] & \frac{r}{2}\left[\pi-3\right] & \left[\frac{r^2}{16}\left[3\pi^2-8\pi-4\right]\right] & \left[\frac{1}{8}\left[\pi^2+2\pi-16-r\left[\pi^2-2\pi-4\right]\right]\right] & \left[\frac{1}{8}\left[\pi^2+2\pi-16-4r\left[\pi-3\right]\right]\right] & \left[\frac{r}{8}\left[\pi^2+2\pi-16-\frac{r}{2}\left[3\pi^2-8\pi-4\right]\right]\right] \\ -\left[\frac{\pi^2}{8}-1\right] & -\left[\frac{\pi}{4}-1\right] & -\frac{r}{2}\left[\pi-3\right] & \left[\frac{\pi^2}{8}-1\right] & \left[\frac{\pi}{4}-1\right] & \frac{r}{2}\left[\pi-3\right] \\ -\left[\frac{\pi}{4}-1\right] & -\left[\frac{\pi^2}{8}-1\right] & \left[\frac{r}{8}\left[\pi^2-2\pi-4\right]\right] & \left[\frac{\pi}{4}-1\right] & \left[\frac{\pi^2}{8}-1\right] & -\left[\frac{r}{8}\left[\pi^2-2\pi-4\right]\right] \\ \left[-\frac{r}{8}\left[\pi^2-2\pi-4\right]\right] & -\frac{r}{2}\left[\pi-3\right] & \left[\frac{r}{8}\left[\pi^2+2\pi-16-\frac{r}{2}\left[3\pi^2-8\pi-4\right]\right]\right] & \frac{r}{2}\left[\pi-3\right] & -\frac{r}{8}\left[\pi^2-2\pi-4\right] & \frac{r^2}{16}\left[3\pi^2-8\pi-4\right] \end{bmatrix} \begin{bmatrix} v_1 \\ u_1 \\ \theta_1 \\ v_2 \\ u_2 \\ \theta_2 \end{bmatrix}$$

$$\frac{r^7}{(EI_z)^3}\left[\frac{\pi^3}{32}-\frac{5\pi}{2}+1\right] \tag{12}$$

Above is the element stiffness matrix obtained.

By writing the Value of β as 90^o and also solving the above equation we obtained the element stiffness matrix for a special case $\beta = 90^o$.

$$\begin{bmatrix} P_1 \\ Q_1 \\ M_1 \\ P_2 \\ Q_2 \\ M_2 \end{bmatrix} = \begin{bmatrix} 42.87 & -39.37 & -9.48r & -42.87 & 39.37 & 9.48r \\ -39.37 & 42.87 & 12.98r & 39.37 & -42.87 & -12.98r \\ -9.48r & 12.98r & 5.45r^2 & 12.98r & -9.48 & -1.95r^2 \\ -42.87 & 39.37 & 12.98r & 42.87 & -39.37 & -12.98r \\ 39.37 & -42.87 & -9.48r & -39.37 & 42.87 & 9.48r \\ 9.48 & -12.98r & -1.95r^2 & -12.98r & 9.48r & 5.45r^2 \end{bmatrix} \begin{bmatrix} v_2 \\ u_2 \\ \theta_2 \\ v_2 \\ u_2 \\ \theta_2 \end{bmatrix} \tag{13}$$

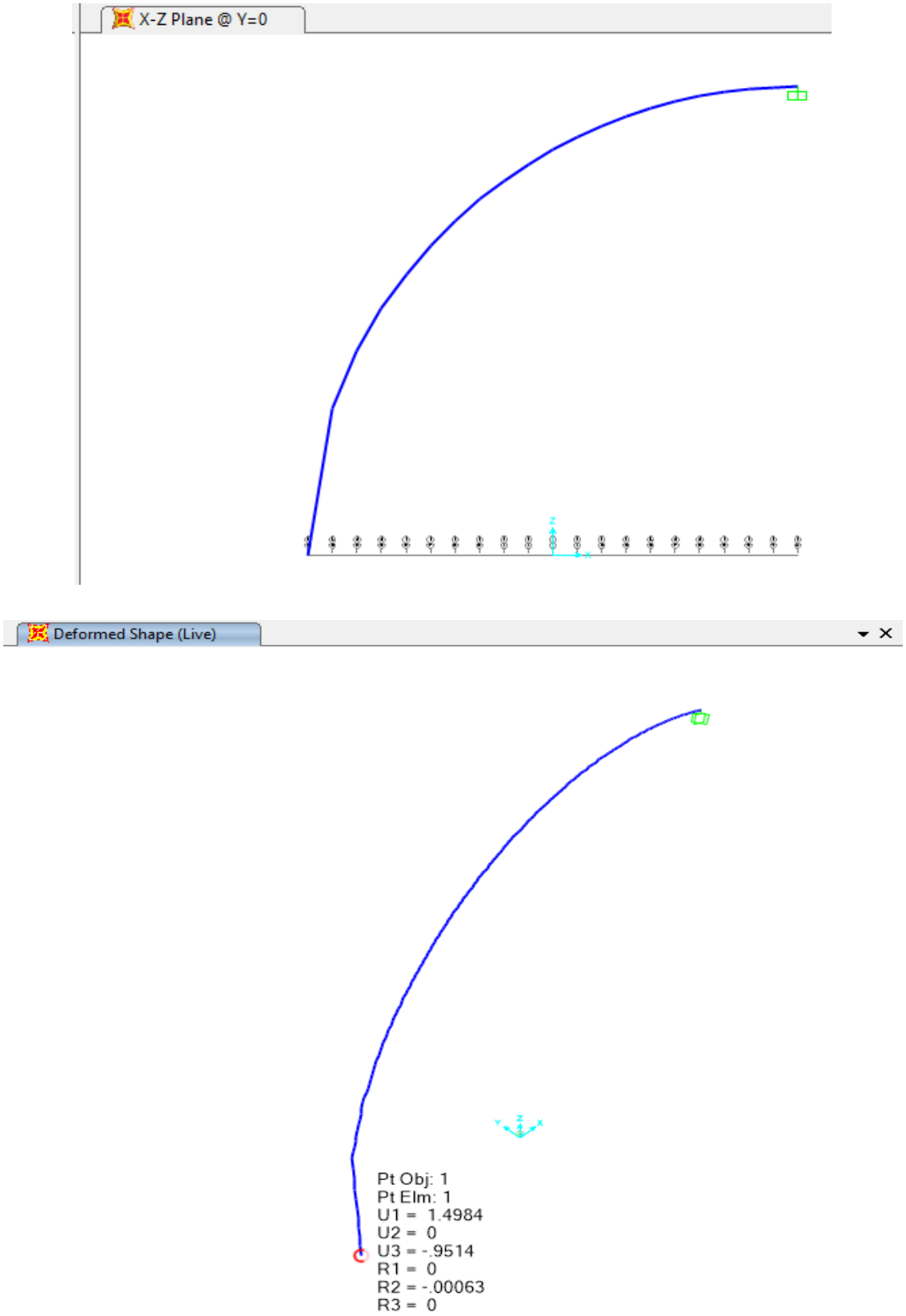

Figure 4: Model in SAP2000

Numerical Example

By analysing simple numerical example, equations for stiffness matrix are validated. A curved beam having radius of curvature 3000 mm and cross section of 500x500 mm,M30 and modulus of elasticity(E)= $5000\sqrt{f_{ck}}$. M30 is the grade of Concrete, f_{ck} is the characteristic strength of concrete.

Result through current direct stiffness matrix, the displacement in horizontal direction at the end point=1.4867 mm. Displacement in downward direction at the end point = 0.946 mm. Rotation at he end point = -0.00063(R). The curved beam model is generated in SAP2000 as shown in Fig. 4. Fig. 4 shows the curved beam exmaple which free at node 1 and supported at node 2. The horizontal and vertical loading has been applied at node 1 of unit magnitude. Here in Fig. 4, U_1 and U_3 are the deformations in horizontal and vertical direction. R_2 is the roation about the axis which out of plane of the figure.

Results from the software SAP200 are given as: The displacement in horizontal direction at the end point = 1.498 mm; Displacement in downward direction at the end point = -0.9514mm; Rotation at he end point = -0.00063(R).

Conclusion

An element stiffness matrix has been derived by using of strain energy concept and knowledge of basic mechanics. Two nodes of the curved beam element having 3 degrees of freedom, (1) Moment, (2) Vertical displacement and (3) horizontal displacement. The obtained final element stiffness matrix will be useful for solving variety of curved beam examples applied in practice such as arches, hooks, and curved traffic poles subjected to various loading conditions. Numerical example has been demonstrated for the validity of the equations and compared with the software results. The problem is analyzed using direct stiffness approach.

Nomenclature

U	=	Strain Energy of the elastic body
AE	=	Axial Rigidity
M	=	Moment

δ	=	Displacement
θ	=	Rotation
M_1, M_2	=	Moment occurred at node 1 and 2 respectively
Q_1, Q_2	=	Forces acting parallel to the axis of the curve beam
ds	=	Arc length
R	=	Radius of curvature
r	=	Radial coordinate along the curve
$d\varphi$	=	Subtended angle
P_1, P_2	=	Normal forces acting at node 1 and node 2 respectively
β	=	Total angle along the curve
δ_{VP}	=	Displacement in vertical direction due to load P
δ_{HP}	=	Displacement in Horizontal direction due to load P
δ_{VQ}	=	Displacement in vertical direction due to load Q
δ_{HQ}	=	Displacement in Horizontal direction due to load Q
δ_{VM}	=	Displacement in vertical direction due to Moment M
δ_{HM}	=	Displacement in Horizontal direction due to Moment M
v_1, v_2	=	Displacement in normal direction to the axis of curved beam at node 1 and 2
u_1, u_2	=	Displacement in perpendicular direction to the axis of curved beam at node 1 and 2
θ_1, θ_2	=	Rotations at node 1 and 2
θ_{P1}, θ_{P2}	=	Rotations at node 1 and 2 due to load p
θ_{Q1}, θ_{Q2}	=	Rotations at node 1 and 2 due to load Q
θ_{M1}, θ_{M2}	=	Rotations at node 1 and 2 due to moment M
P_1, P_2	=	Loads at node 1 and 2 in normal direction
Q_1, Q_2	=	Loads at node 1 and 2 in parallel direction
M_1, M_2	=	Moments at node 1 and 2

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Behavior of Structural Systems for High Rise Buildings

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Abstract

Rapid growth of population has encouraged development of tall buildings around the world. For higher ductility and energy dissipation under lateral forces, effective structural systems like rigid frame and shear wall systems are employed in buildings.

The structural system of a tall building is designed to deal with vertical gravity loads and mainly the lateral loads caused by wind and seismic activity. The structural system consists of only the members designed to carry loads. All other members which do not participate in carrying loads are referred to as non-structural members.

This study focuses on choice of structural system with different parameters like storey drift, storey shear and maximum storey displacement.

Key words

storey drift, storey shear, maximum storey displacement,structural system

Introduction

Population of India is increasing at an alarming rate (about 1.2% per year) and now we are1.34 billion people. This large population not only needs jobs but also needs housing and other infrastructure facility. Tall structures may serve the requirement in metropolitan cities. As the height of the building increase the lateral resisting system becomes more important than the structural systems that resist the gravitational loads. There is various types of structural system are used in high rise building.

The lateral resisting systems are widely used in the world are rigid frame system, Shear wall system, Braced structures, Tubular system, Core system, Outrigger system. This work focuses on study of various parameters compare with different structural system. Analysis of

building involves parametric study of maximum storey displacement, storey drift, and storey shear.

Storey Drift: It is defined as ratio of displacement of two consecutive floors to height of that floor. It is very important term used for research purpose in earthquake engineering.

Storey Displacement: Total displacement of any storey with respect to ground and there is maximum permissible limit prescribed in IS codes for buildings.

Storey Shear: It is the sum of design lateral forces at all levels above the storey under consideration.

Objective

1) To understand behavior of various structural system used in high rise building.
2) Comparative study on various structural system used in conventional practice approach.
3) Parametric study and its response comparison for considered structural system.
4) To study of performance on different structural system used in tall structure.

Building System under Study

The building has been modeled considering the building data as tabulated.

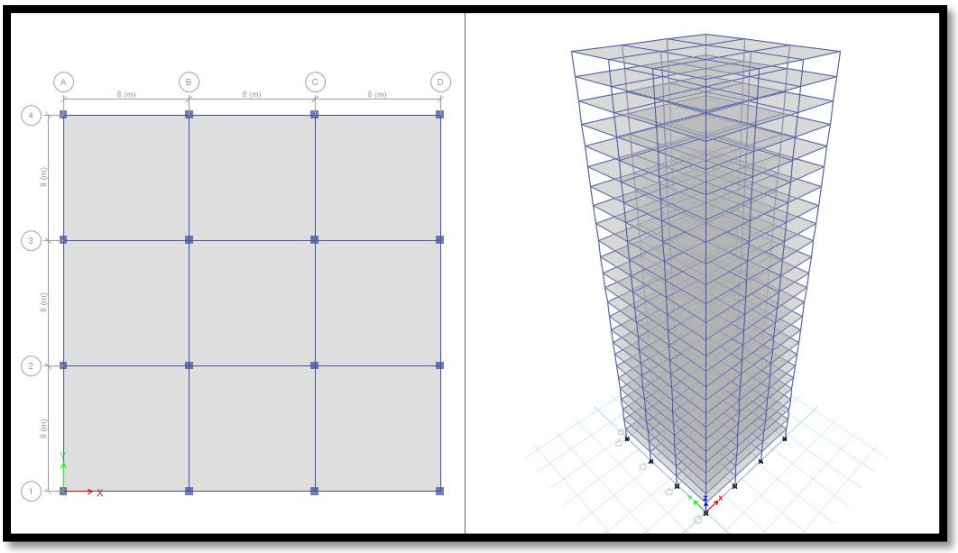

Figure 1: Plan and Elevation of building

Plan dimension	24 m X 24 m
Height of typical storey	3 m
Height of base storey	3 m
Number of bays in X direction	3
Number of bays in Y direction	3
Width of each bay in X direction	8m
Width of each bay in Y direction	8m
Slab thickness	150 mm
Column size	500 mm X 500 mm
Beam size	500 mm X 300 mm
Shear wall thickness	250 mm
Live load	3 KN/m^2
Location	Vadodara
Earthquake data	IS 1893 (part 1) – 2002
Type of soil	Medium soil
Importance factor	1.5
Response reduction factor	5
Type of structural systems	1) Rigid frame structural system 2) Shear wall structural system
Seismic Zone Factor	0.36
Dead load	as calculated by the software

Table 1: Building data

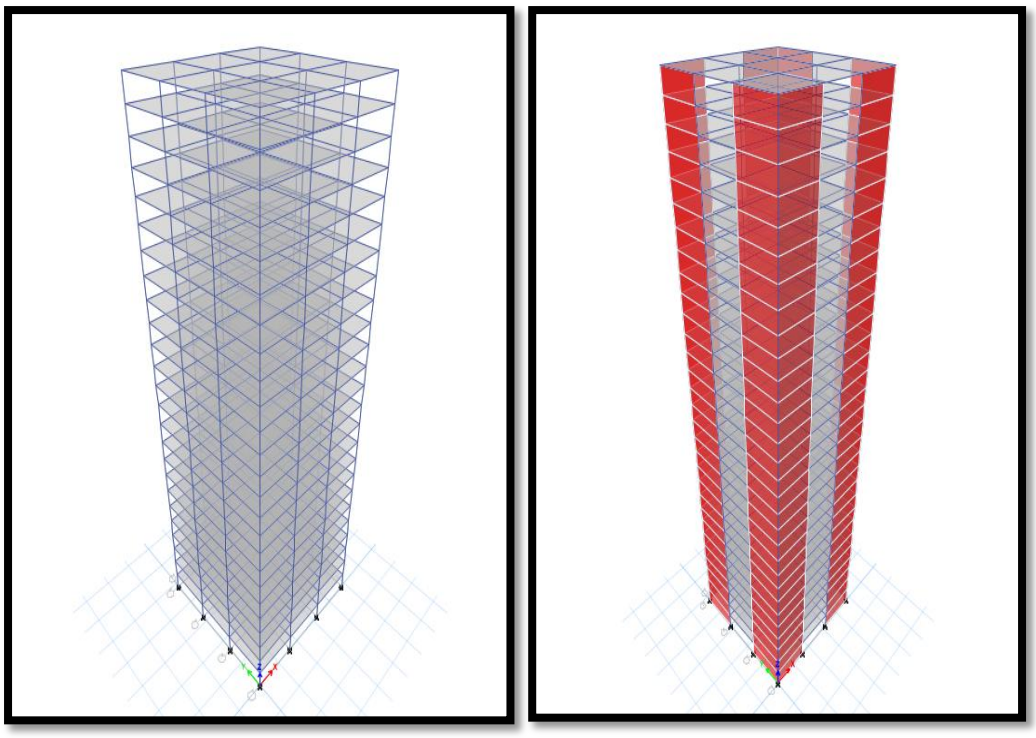

Figure 2: Elevation of rigid frame and shear wall structural systems

The modeling and analysis of various structural systems were carried out in software. The software was used to model and assess the effectiveness of various structural systems under lateral loadings. Seismic loading was applied to the structures. The structural systems that were modeled and analyzed are:

1. **Rigid frame system:** The word rigid means ability to resist the deformation. Rigid frame structures can be defined as the structures in which beams & columns are made monolithically and act collectively to resist the moments which are generating due to applied loads.
2. **Shear wall system:** In structural engineering, a shear wall is a structural system composed of braced panels (also known as shear panels) to counter the effects of lateral load acting on a structure. Shear wall is a structural member used to resist lateral forces.

Five models of varying stories were analyzed for rigid frame structural system. The numbers of stories analyzed for the system are 5 storeys, 10 storeys, 15 storeys, 20 storeys, 25 storeys.

Four models of varying stories were analyzed for Shear wall structural system. The numbers of stories analyzed for the system are 10 storeys, 20 storeys, 30 storeys, 40 storeys. For Shear wall structural system, the orientation of the shear wall is considered at the corners of the building with L-shaped.

Maximum permissible storeydisplacement and permissible storey drift are calculated from IS: 1893 – 2002 and IS: 456 – 2000.

Maximum permissible storey displacement is limited to H/500. Where, H – total height of building.

Maximum permissible storey drift is limited to 0.004 h. Where, h – storey height.

In this article all these different heights achieve compare all different parameters like maximum storey displacement, storey shear and storey drifts.

Results and Discussion

Rigid Frame Structure

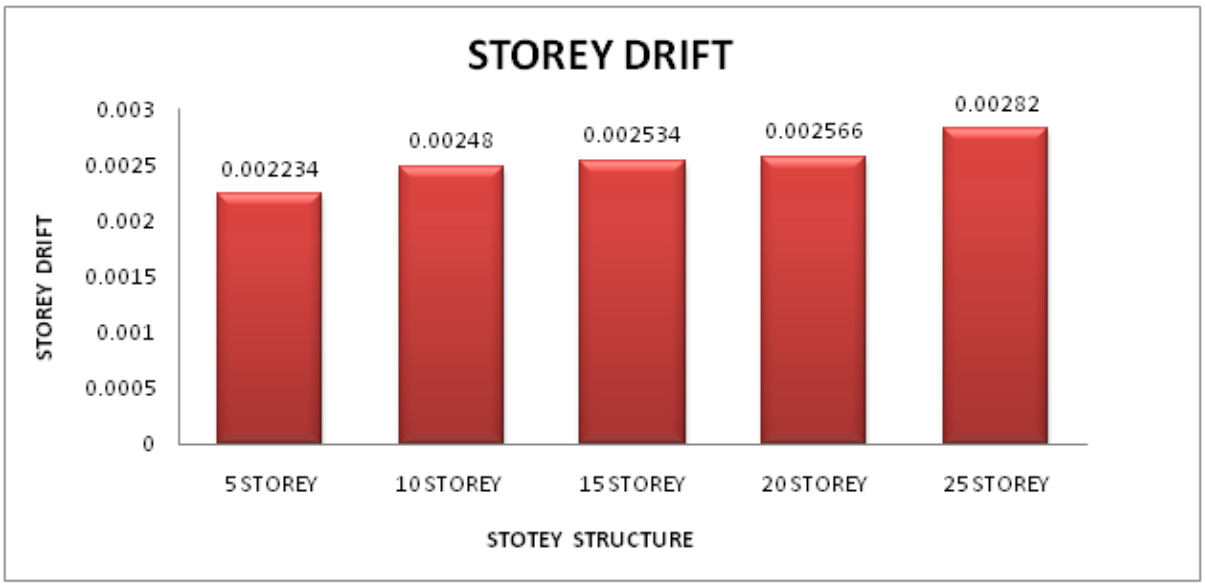

Figure 3: Storey Drift

STOREY STRUCTURE	STOREY DRIFT
5 STOREY	0.002234
10 STOREY	0.00248
15 STOREY	0.002534
20 STOREY	0.002566
25 STOREY	0.00282

Table 2: Storey Drift

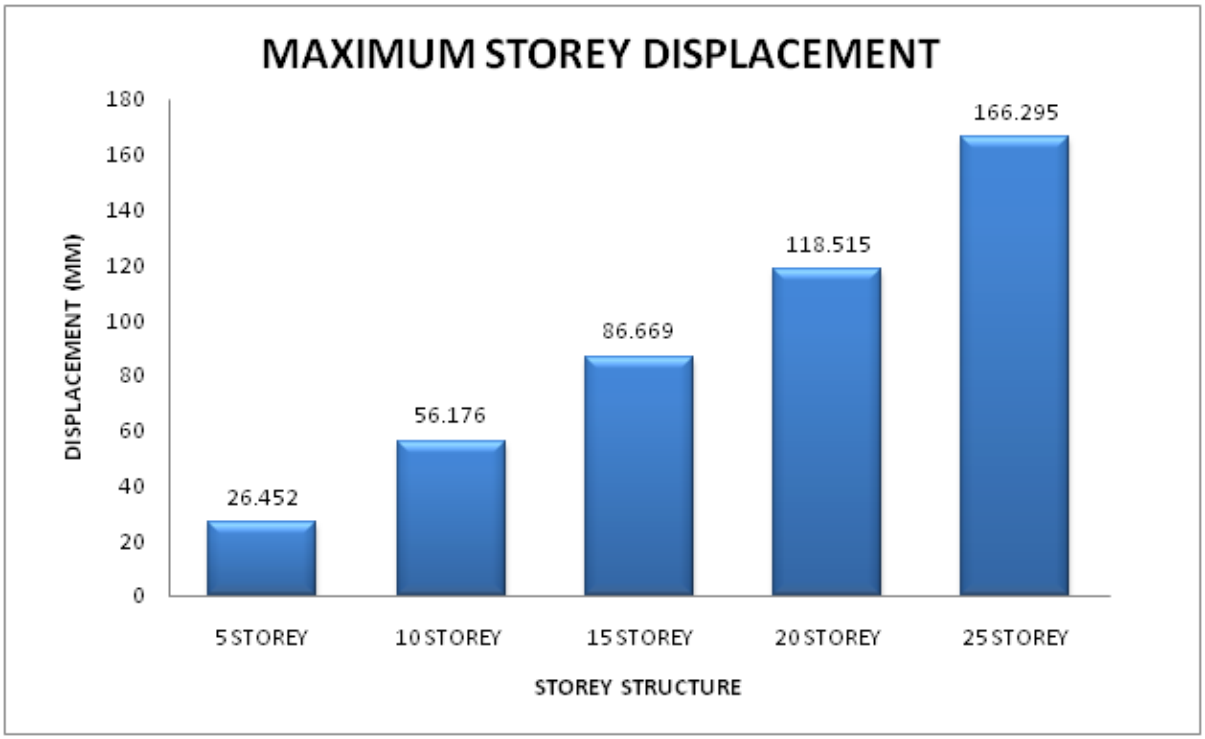

Figure 4: Maximum Storey Displacement

STOREY STRUCTURE	DISPLACEMENT (MM)
5 STOREY	26.452
10 STOREY	56.176
15 STOREY	86.669
20 STOREY	118.515
25 STOREY	166.295

Table 3: Maximum Storey displacement

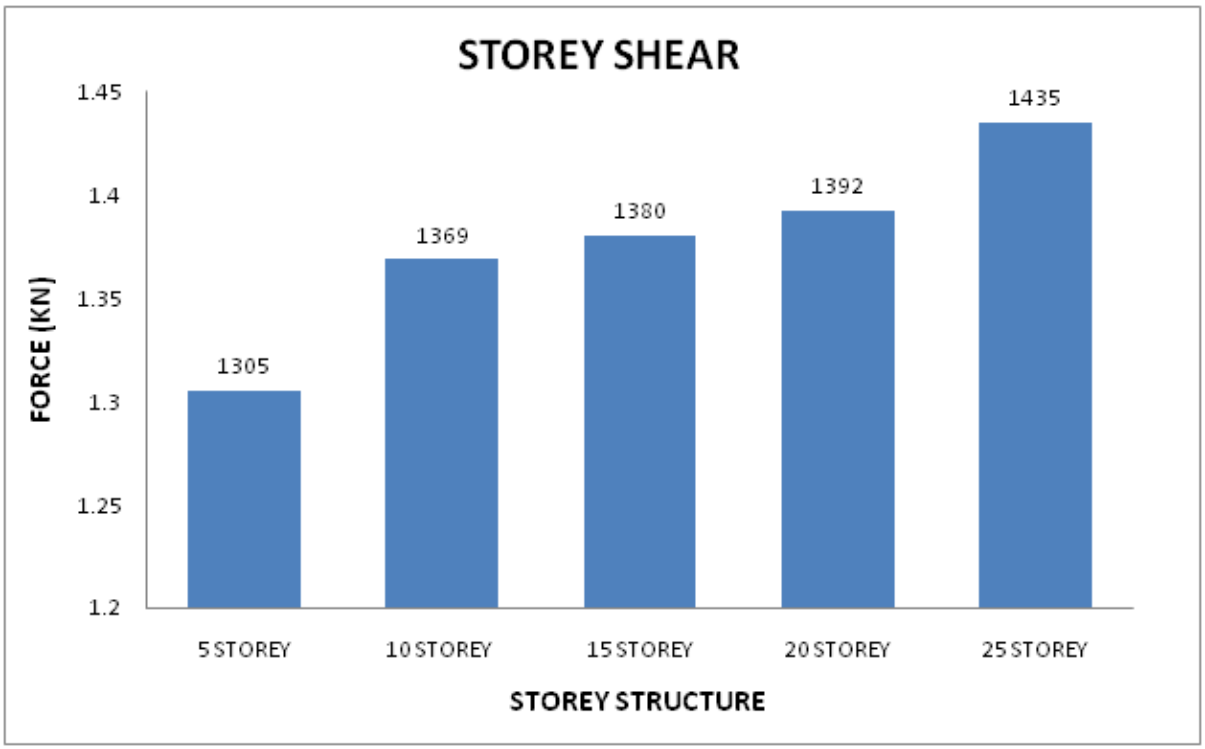

Figure 5: Storey Shear

STOREY STRUCTURE	FORCE (KN)
5 STOREY	1305
10 STOREY	1369
15 STOREY	1380
20 STOREY	1392
25 STOREY	1435

Table 4: Storey Shear

Shear Wall Structure

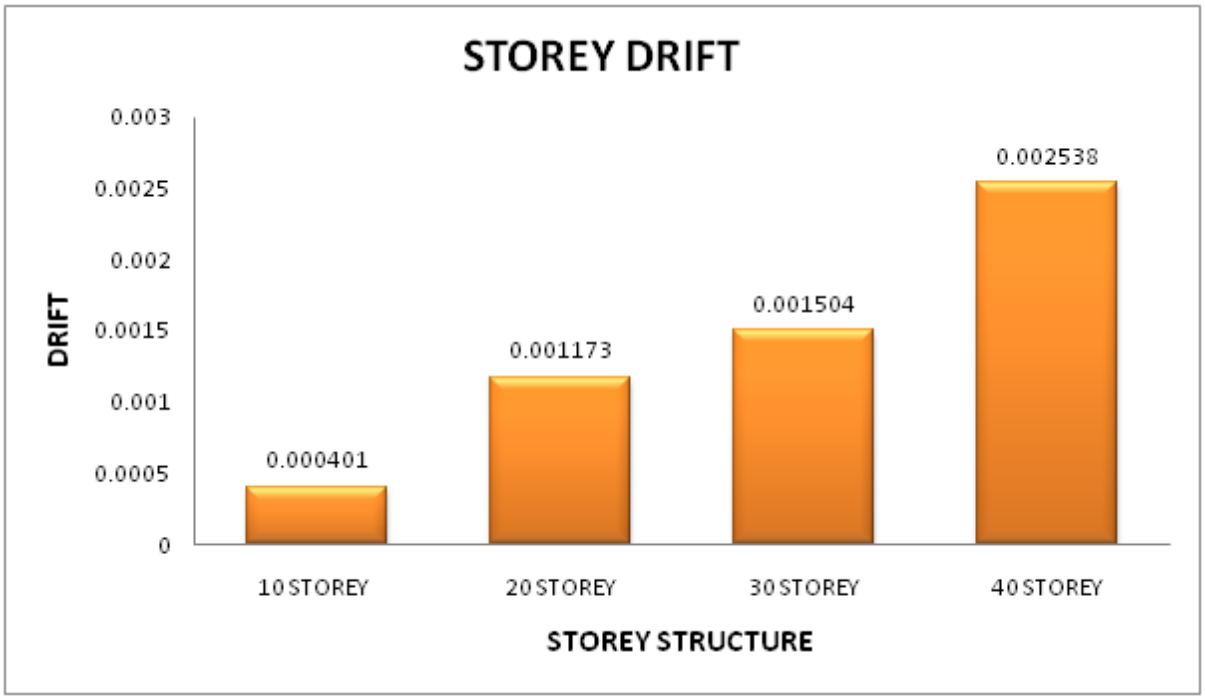

Figure 6: Storey Drift

STOREY STRUCTURE	DRIFT
10 STOREY	0.000401
20 STOREY	0.001173
30 STOREY	0.001504
40 STOREY	0.002538

Table 5: Storey Drift

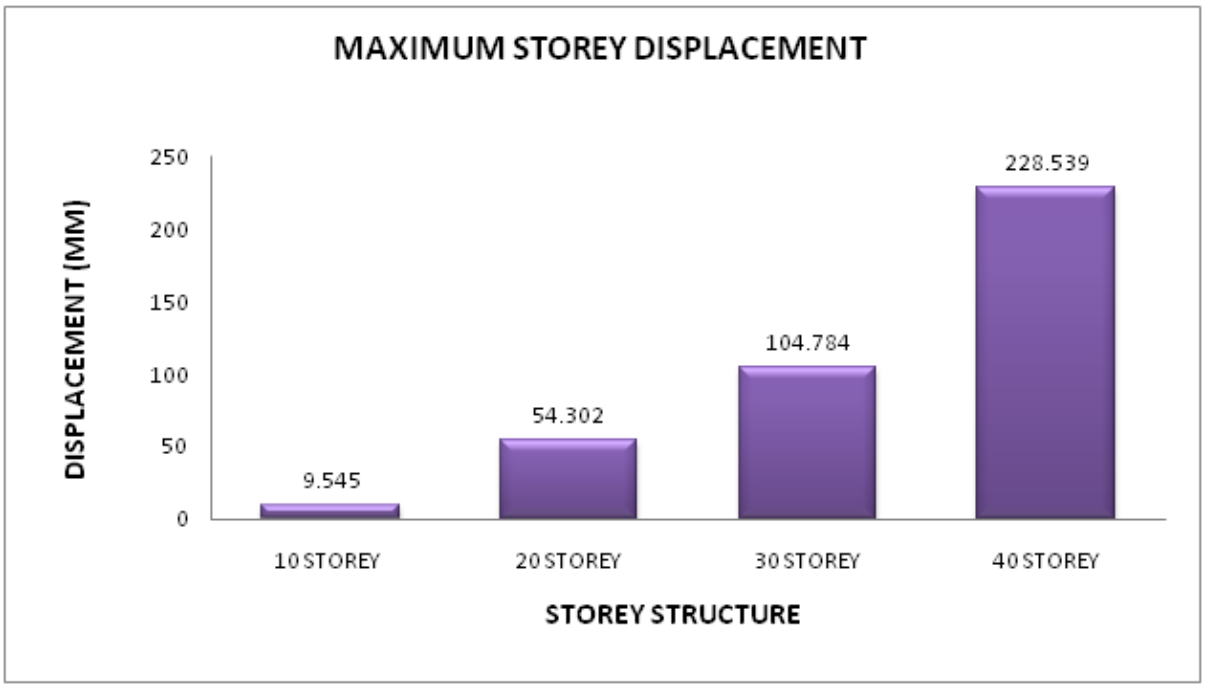

Figure 7: Maximum Storey Displacement

STOREY STRUCTURE	DISPLACEMENT (MM)
10 STOREY	9.545
20 STOREY	54.302
30 STOREY	104.784
40 STOREY	228.539

Table 6: Maximum Storey Displacement

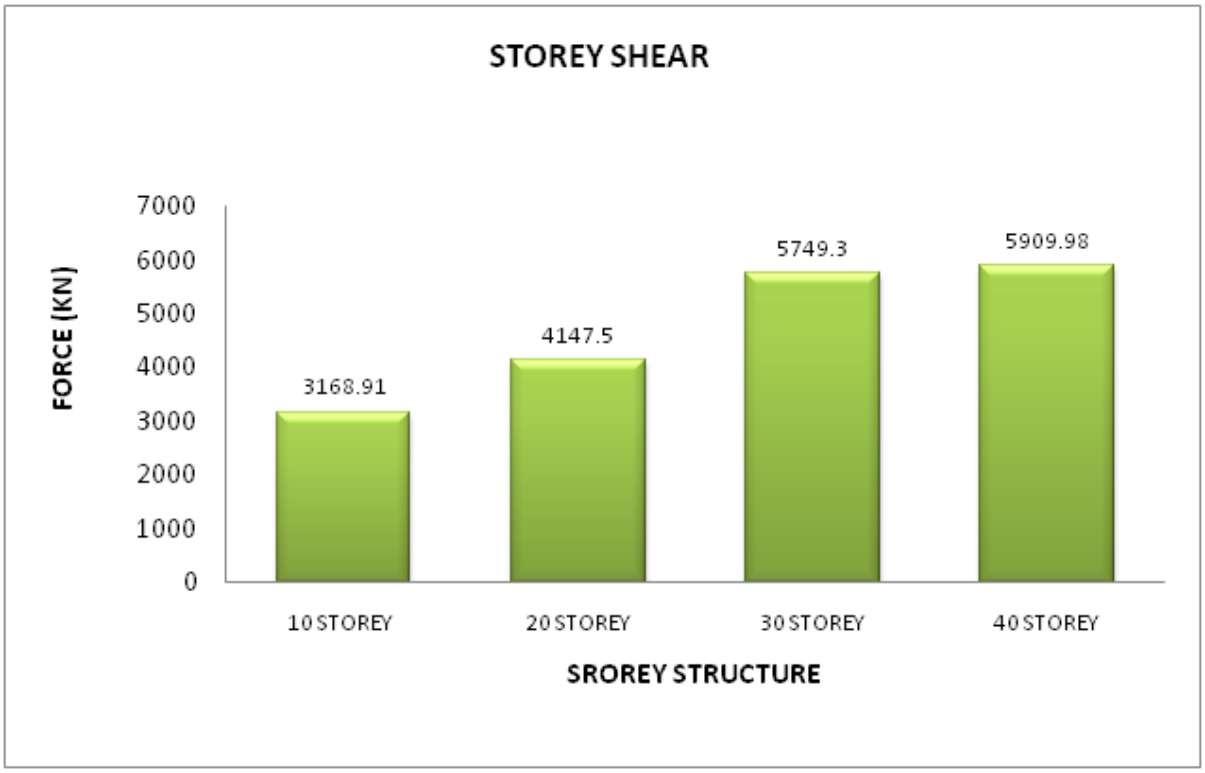

Figure 8: Storey Shear

STOREY STRUCTURE	FORCE (KN)
10 STOREY	3168.91
20 STOREY	4147.50
30 STOREY	5749.30
40 STOREY	5909.98

Table 7: Storey Shear

Discussion

Under the seismic loads as the height of the structure increase the Storey drift, Maximum storey displacement and Storey shear also increases. Rigid frame structure is recommended up to 25 stories. Storey drift, maximum storey displacement and storey shear for the models are within the limit specified by IS-1893:2002 (Part I).

Conclusions

1) In this study is carried out according to earthquake code IS-1893 (part 1):2002 and analysis is carried out by taking regular plan of building.

2) The key idea in limiting the seismic effect in a tall building is by changing the structural system of the building into something more rigid and stable to confine the deformation and increase stability.

3) The maximum storey displacement is reduced by the use of shear wall structure as compare to rigid frame structure.

4) From the selected structural system for analysis, shear wall structural system is most efficient.

5) Rigid frame structural system is more appropriate than shear wall structural system for low rise building considering economical aspect.

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Development, Design, Applications and Handling of Tesla Coil Transformers: A Review

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Abstract

The aim of this paper is to highlight the development of Tesla transformer throughout the decades since its first patented design and to discuss the designing parameters required in construction and manufacturing of Tesla transformers and to see the applications where different types for the same transformers are used as per different specifications. The paper will also give information on health hazards or how to take personal care while operating a Tesla coil. The paper shall as well try to provide an understanding how the Tesla Coils can be used in various applications in brief. Also the designing of Tesla Transformers in comprehensive stepped flow chart for the clear understanding of readers has been presented in successive sections of this journal article. The article being 'A Review ' paper does not include detailed explanation about the designing of the Tesla Coils and hence a numerous parameters which might be difficult to comprehend for common readers have been excluded and instead easy methodology for explanation has been adopted for better understanding.

Keywords

Tesla coil, disruptive voltage, spark gap, corona, resonating transformer, solid state Tesla coil, magnifier circuit

Indices

H.V. =high voltage

L.V. = low voltage

CRT= cathode ray tube

IF=infrared

RF=radio frequency

W.P.T=wireless power transfer

Parameters

λ/4= quarter wavelength in feet

c= propagation speed of wave front or $9.84x10^8$ feet/sec or $2.998x10^8$ m/s

f_0= resonant frequency

L/T = Length per turn of wire in inches

D = Diameter of secondary coil form

d = Diameter of wire with insulation and inter-winding distance

N = Required number of turns of wire

Ls = Inductance of secondary coil in μhenries

A = Radius of coil form in inches

Cs = Self-capacitance of secondary coil in farads

H = Required height of winding in inches

DCΩ= Total DC resistance of the winding in ohms

NS = Number of layers (strands) of wire used

TA= Ambient temperature in Celsius

Ω/ft= DC resistance of one foot of selected wire gauge

AC Ω = Total AC resistance (skin effect only) of the winding in ohms

Rt = Total resistance of secondary winding in ohms

Ct = Terminal capacitance in farads

Cp = Maximum usable primary capacitance for selected step-up transformer

IR = Rated output current of step-up transformer in amps

VR = Rated output voltage of step-up transformer in volts

BPS = Breaks per Second produced by spark gap

Cpt = Additional primary tuning capacitance in farads

W = *A*/ cos θ

θ = angle of incline from horizontal

Introduction

The Tesla coil is basically an electrically resonating transformer circuit which is generally excited by different methods or is tuned singly or doubly or in some cases triply coupled. The Tesla transformer was designed by the scientist Nikola Tesla in 1891. They are used to produce a high voltage A.C. Supply with changeable high frequency and low current which is used in a numerous applications in industries, laboratories, radios and wireless power transfer technologies. This piece of the paper for the most part contains the historical backdrop of the Tesla coil and how it was made for all intents and purposes accessible for genuine use outside the lab. Researcher Nikola Tesla created the Tesla Coil and first showed it in broad daylight in 20th May of 1891 at the AIEE at Columbia College, New York. The primary licensed circuit had all the essential components i.e. H.V. essential, capacitor, start exciter and coreless oscillating transformer [1]. By the examination it was discovered that the transformers utilized as a part of vast power lattice structure which worked diversely at high frequency when contrasted with low frequencies [2]. The iron core utilized as a part of lower level of power supply suffered from energy losses, and if not insulated properly it could pose dangerous to the person handling it. So another transformer without a solid core was created freely by Nikola Tesla and researcher Elihu Thomson which was known as "oscillating transformer" and the coil circuit to work it to deliver high voltage supply. The Tesla coil was essentially concocted amid endeavor of making a remote lighting network i.e. wireless power supply network [3,4]. However Tesla was not the first to build up this circuit rather Henry Rowland built up a start hole thunderous transformer circuit in 1889. Be that as it may, Nikola Tesla was the main visionary who saw the pragmatic uses for it and in this way protected it. Tesla awed gathering of people in his many addresses held at lofty logical traditions by indicating them brush releases and streamer releases, additionally he demonstrated that H.F. streams did not make vibe of stun by applying a few kilovolts his own particular body which made his body to shine up like that of crown in a dull room. The Tesla coil fundamentally made to accomplish the W.P.T however these days the utilization of these is across the board in radios, medication, the stage, training, high voltage creation, spillage discoveries, and ignitron circuits in bend welding applications and so forth[5,6]. The utilizations and uses of Tesla coil will be clarified in much detail in up-coming segments of the writing.

Different Types of Tesla transformers

The Tesla coil circuits can be classified by the methods of excitation employed in that particular circuit, what circuit is used to apply the current to primary of the resonant transformer.

1) Spark-gap Tesla coil

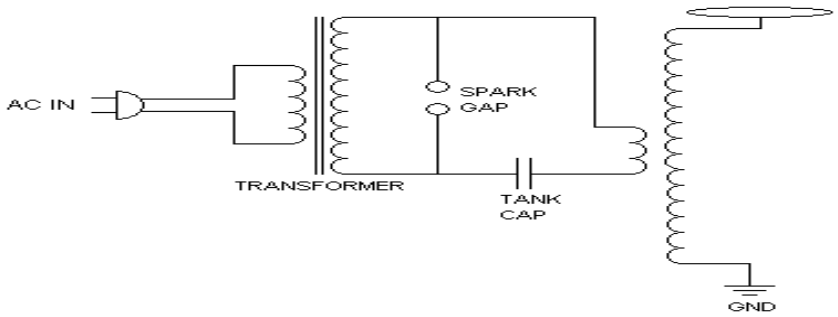

Figure 1: Tesla coil with spark - gap

This kind of coil circuit utilizes a start hole/spark gap to turn on the essential twisting of the circuit. This flagged beat drive makes a H.V. wave at the yield. The detriment of start hole is the treatment of high essential streams, boisterous operation, ozone gas, and high temperature. That is the reason they require cooling framework regularly. Likewise the Q-factor and yield voltage lessens in this kind of development [7].

1-A) Stationary excited spark gap

In this sort of development, circuits regularly utilize D.C. voltage source to charge the capacitor and H.V. pulses are produced to trigger the start hole which allows the control of start rate and energizing voltage. The economically accessible start holes are encased in protecting gas environment like SF_6 which promote more help in decreasing the length and accordingly the loss of energy.

1-B) Rotating Spark gap

This development comprises of a start hole having cathodes (electrodes) around the surface of a wheel which is pivoted at rapid by an engine that makes releases or circular segments when they go by a relentless terminal. The quick division speed of the cathodes douses the sparks/arcs rapidly which helps in getting higher voltages at the yield. In this type the wheel

is rotated by a synchronous machine (motor) with the goal that the anodes are turned at a uniform speed and an unadulterated sine wave is gotten.

2) Solid State Tesla Coil (SSTC)

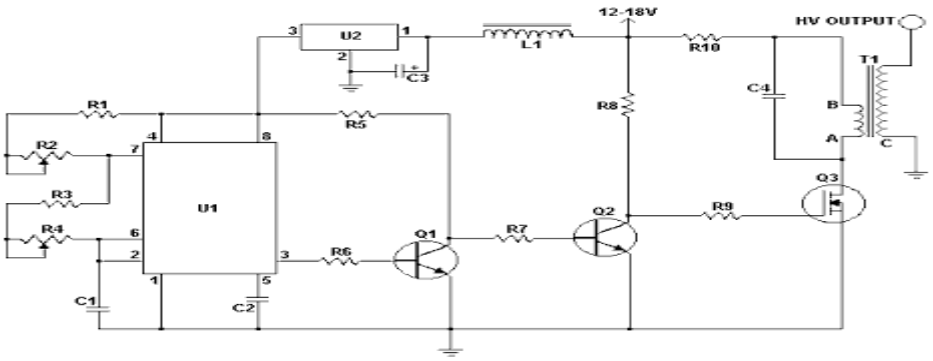

Figure 2: Solid state Tesla coil

They utilize semiconductor gadgets like thyristors (S.C.R), transistors (IGBT or MOSFET) to give switching beats/pulses of current from a DC source to primary of the Tesla Transformer. They give pulsed starting without the detriment of a spark gap i.e. uproarious operation, high temperature, and low proficiency (efficiency). The points of interest being calibrating or control of voltage, current and excitation waveforms [8,9].

2-A) Solo resonant solid state Tesla Coil (SRSSTC)

In this development the essential does not comprise a condenser as isn't a tuned circuit yet the auxiliary is just the tuned one. The pulses acquired by the power semiconductor gadgets connected to essential energize the auxiliary winding's tuned circuit. SRSSTC are more straightforward to plan yet the hindrance is the low Q-factor and can't create voltage level as high as a DRSSTC.

2-B) Double Resonating Solid State Tesla Coil (DRSSTC)

The circuit is like the double tuned start-hole development, with the exception of that set up of a start excitation a power semiconductor exchanging gadgets are utilized. The capacity of this kind of circuit is like double tuned start energized circuit, which yields higher Q-factor and create high voltage from the given input control.

2-C) Musical or Singing Tesla Coil

Figure 3: Musical Tesla coil

This is the coil which can be played like a musical instrument with its H.V. output discharges reproduce or creating the very basic musical tones. The current signal in form of the pulses applied to the primary are tuned or modulated at an audio rate by a power semiconductor interrupter circuit which causes the arc from the H.V. terminal to emit sounds of different musical notes. So far only basic chords have been produced so the coil itself cannot function as a loud speaker. Therefore complex music or vocal sound is possible with this circuit. So a keyboard with MIDI interface is needed to control the sound output. Such types of Tesla coils are built for entertainment purpose only [10,11].

3) Continuous Wave

In these kind of development the transformer is driven by a closed loop (feed-back) oscillator which gives a sine wave current to primary winding of the transformer. The primary here acts a tank circuit of the oscillator and the circuit carries on like a radio transmitter. This circuit gives an unadulterated, ceaseless sine wave at the yield. Here the vacuum tubes are for the most part utilized rather than control transistors due to their much hearty development.

4) Two coil or Double-tuned / resonant circuits

These days all the business Tesla loops/coils utilize doubly tuned transformer. The L.V. winding is furnished with current heartbeats, auxiliary winding that gives high yield voltage. The expression "Tesla Coil" is for the most part alluded to these sort of circuits [12].

5) Three coil or triple-tuned / resonant circuits or Magnifier circuits

In this construction id based on Nikola Tesla's magnifying transmitter circuit developed during 1898-1900 in Colorado Springs Lab. This consists of a two coil air core transformer with the secondary connected to a third coil not magnetically coupled to other two. This third

coil is also called extra coil or the resonator coil and is series fed and resonates with its own capacitance. This type of construction has limited use in a few practical applications [13].

Type	Sub-type			Designing complexity
Spark Excited	Spark-excited gap	Rotary Spark gap	-	Easiest and most basic type
Switched or Solid State Tesla Coil	Single resonant solid state	Double Resonant Solid State	Musical or Singing	Quite difficult (as the components used need perfect coordination to function properly)
Continuous Wave	-	-	-	Moderately difficult
Two coil or Double-tuned / resonant circuits	-	-	-	Somewhat complex (as proper insulation has to be provided to windings as there two different primaries and their dimensions may also vary)
Three coil or triple-tuned / resonant circuits or Magnifier circuits	-	-	-	More complex than double tuned circuit

Table1: Comparison Table from Designer's P.O.V for manufacturing of Tesla Coil

Development of Tesla Coils over the years

The Tesla coils have themselves experienced various adjustments since its initially patented model. From the extremely fundamental spark energized Tesla transformers with sub-divisions like static and rotating switches which had issues of low quality factor and low

yield voltage, the following change to circuits was the use of power-semiconductor devices with microcontrollers to give the quick exchanging of these components, so the operation is noiseless and the fine control and tuning of output voltage is achievable. Next the continuous wave Tesla coils helped in accomplishing the unadulterated/pure sinusoidal output voltage. The double tuned and triple tuned Tesla coils have discovered their applications in current circumstances. One of the most recent advancement of Tesla transformer is the D.C. Tesla coil which evacuates the massive transformer part which is supplanted by a battery, spark gap is supplanted by a solid state devices, and is fit for auto-tuning itself [14].

Operation of a basic spark-excited Tesla coil with necessary equations

For the testing of electrical instruments for switching waves (surges), high frequency, H.V. damped oscillations are necessary which need high voltage Tesla transformer circuit. The benefits of using these Tesla coil circuits are:

A) The transformers are devoid of a solid core and hence saving in parameters like bulkiness and expense,

B) Pure sinusoidal power voltage signal at the output,

C) Gradual production of voltage over initial cycles and hence no damage due to sudden surges, and

D) Equal voltage distribution over the coils due to subdivision of coil stack into a number of parts.

The common arrangement of a circuit is given in the figure shown below. The primary is fed from a direct or alternating power source through the capacitor Ci. A spark-gap G connected across the primary is excited at the desired voltage V which induce a high disruptive voltage in the secondary.

The L.V. and the H.V. windings (L1 and L2*)* are wound on an insulated bobbin with no core (air-cored) and are oil immersed. The windings are tuned to a frequency of ten to hundreds of kilo Hertz by the help of the capacitors C and Ci .

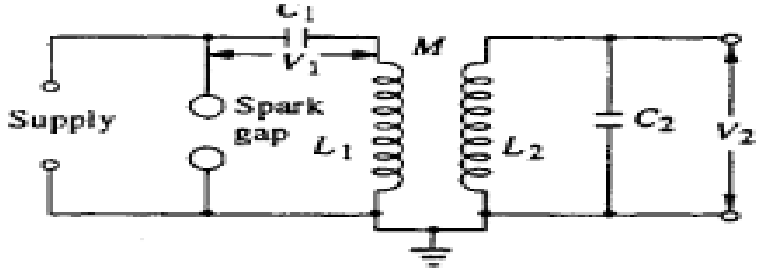

Figure 4: Tesla coil equivalent circuit

The output voltage $V_{2\ is}$ a function of individual inductances and capacitances and mutual inductance M. If i1 and i2 are the circuit currents and V1 and V2 are the input and output voltages respectively then we get the following equations [14,15]

$$V_1 = \frac{1}{C1}\int_0^t i1\ dt + L_1\frac{di1}{dt} + M\frac{di2}{dt} \quad (1)$$

$$0 = \frac{1}{C2}\int_0^t i2\ dt + L_1\frac{di2}{dt} + M\frac{di1}{dt} \quad (2)$$

From the Laplace transformation of the equations (1) and (2) we get:

$$\frac{V1}{S} = \left[L1s + \frac{1}{C1s}\right] I_1 + MsI_2 \quad (3)$$

$$0 = [Ms]I_1 + [L_2s + \frac{1}{C2s}]I_2 \quad (4)$$

The output voltage V2 and its Laplace transformation is given by;

$$V_2 = \frac{1}{C2}\int_0^t i2dt \ \ V_2(s) = \frac{I2}{C2s} \quad (5)$$

The solution for equation (5) yields;

$$V_2 = \frac{MV1}{\sigma L1L2C1}.\frac{1}{(\gamma 2)^2 - (\gamma 1)^2}[\cos\gamma 1t - \cos\gamma 2t] \quad (6)$$

Where;

$$\sigma^2 = 1 - \frac{M^2}{L1L2} = 1\text{-}K^2 \quad (7)$$

The roots are given by;

$$\gamma^{1,2} = \frac{\omega 1^2 + \omega 2^2}{2} \pm \sqrt{\frac{\omega 1^2 + \omega 2^2}{2} - [\omega 1^2\omega 2^2(1 - K^2)]} \quad (8)$$

$$\omega_1 = \frac{1}{\sqrt{L1C1}} \ and \ \omega_2 = \frac{1}{\sqrt{L2C2}} \quad (9)$$

Also;

$$W_1 = 0.5\eta C_1V_1^2 = (0.5{*}C_2V_2^2) \quad (10)$$

Therefore;

$$V_2 = V_1\sqrt{\eta\frac{C1}{C2}} \quad [15] \quad (11)$$

Designing of Tesla Transformers

In this section the designing of a spark excited Tesla Coil will be discussed with all the basic parameters which are actually needed to design an actual Tesla transformer .

a)Length of secondary winding

$$\frac{\lambda}{4} = \frac{C}{f0} \quad (12)$$

b) Per turn length

$$L/T = Dp + d \quad (13)$$

c) Number of turns

$$N=\frac{\lambda/4}{L/T} \tag{14}$$

d) Winding height

$$H=N*{}^{L}/_{T} \tag{15}$$

e) Inductance of winding

$$Ls\ (\mu h) = \frac{A^2N^2}{9A+10H} \tag{16}$$

f) Capacitance

$$C_s=\frac{1}{4\pi^2*f0^2Ls} \tag{17}$$

g) DC resistance

$$DC\,\Omega = \frac{\frac{(\lambda/4)*\Omega/ft)}{NS}}{1+[TA-20°C]*0.00393} \tag{18}$$

h) AC resistance

$$AC\,\Omega = \frac{9.96*10-7*\sqrt{fo}}{d} \tag{19}$$

i) Quality of Secondary Winding

$$Q_s = \frac{\omega 0LS}{Rt} \tag{20}$$

j) Resonant frequency of secondary winding

$$f_{so} = \frac{1}{2\pi\sqrt{Ls(Ct+Cs)}} \tag{21}$$

k) Total impedance of the secondary winding

$$Zs=\sqrt{Rt^2+\left(\omega soLs-\frac{1}{\omega so(Cs+Ct)}\right)^2} \tag{22}$$

l) Primary Capacitance

$$Cp = (\frac{IR}{VR}*\frac{1}{BPS}) - Cpt \tag{23}$$

m) Inductance of the primary winding for helically and spirally wound structure and Top Load

$$Ls\ (\mu h) = \frac{A^2N^2}{9A+10H} \tag{24}$$

$$Ls\ (\mu h) = \frac{A^2N^2}{8A+11W} \tag{25}$$

n) Resonant frequency of primary winding

$$fp=\frac{1}{2\pi\sqrt{(Lp+Lpt)(Cp+Cpt)}} \tag{26}$$

o) Resistance and Impedance of the Primary Winding and Spark gap

$$Rge = \frac{8(193.04S+34)}{\pi Ip} \tag{27}$$

$$Zpss = \sqrt{(Rp + Rg)^2 + (\omega pLp - \frac{1}{\omega pCp})} \tag{28}$$

$$Zps = \frac{(\omega pM)^2}{Zs} + Zpss \tag{29}$$

p) Quality factor of primary winding

$$Qp = \frac{\omega p * Lp}{Zpss} \tag{30}$$

All the above formulae for the designing of Tesla transformers hold true, but from manufacturer to manufacturer and applications to environmental conditions the formula for different parameters change as per the necessity, cost, and of course the consumer's requirements. The formulas have been taken from an authentic source of information and many research articles [16-21, 24-25].

Flowchart Representation for the Representation of Designing Procedure

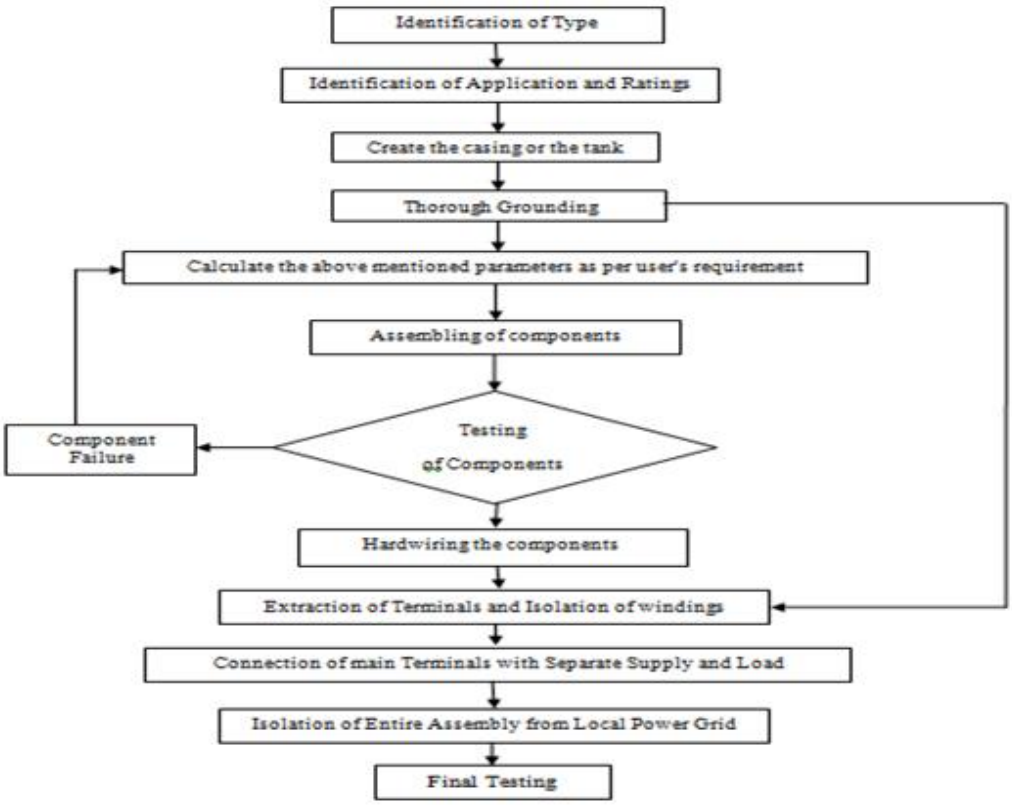

Figure 5: Flowchart describing comprehensive steps for designing and manufacturing of Tesla Transformer

The above flow chart describes how manufacturers design the Tesla Coils according to different applications and user specifications. The complex steps and testing have not been mentioned and a simplified diagram has been presented for better understanding.

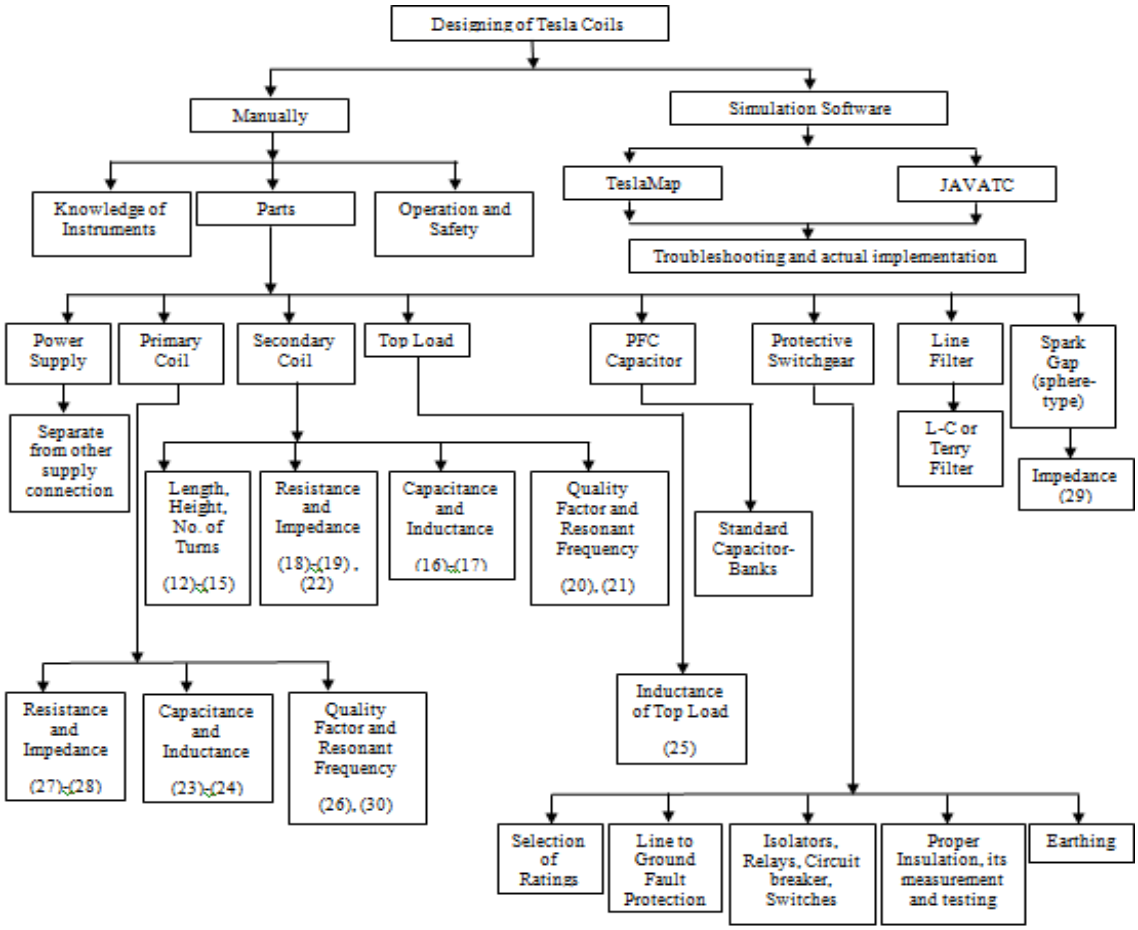

Figure 6: Flowchart Describing comprehensive steps for designing of Tesla Transformer both manually and computerized software

In the above flowchart it can be seen that designing the Tesla Coil manually is a complex procedure requiring a thorough knowledge and a numerous tedious calculations, which in case if one makes errors, may lead to faulty parts and risky operation. Therefore nowadays entire assembly of Tesla Coil is simulated first using softwares mentioned in the flowchart, then troubleshooting in the software itself is done and only after the desired results; the actual Tesla Coil is manufactured according to customer's satisfaction. This shows that using software, valuable time and assets are saved which is not possible in case of a manually produced assembly for the same.

The succeeding sections of the paper shall describe the applications, handling and health hazards associated with Tesla Coils.

Applications of the Tesla coil

1) Wireless power transfer

The remote power exchange was first endeavored to accomplish by Nikola Tesla inside 1891-1900. Transmitting radio power waves restricted to short distances by making suitable magnetic coupling between the turns of primary and secondary. These days this idea is broadly utilized as a part of IF transformers and short range remote power networks. In spite of the fact that the work in WPT is as yet a work in advance however the idea and utilization of the Tesla transformer is the foundation of the research and application of WPT [22].

2) Radio Transmission

The idea of spark energized Tesla coils was first utilized as a part of Radio in 1890's. Many different groups of researchers and scientists prompted an alternate constructional advancement in Tesla coil which was the four-circuit/ quadrupled excited circuit. Be that as it may, they ended up noticeably out of date as the principle part with the coming of vacuum tubes and with its mix with Tesla transformer it is one of the fundamental segments of Radio to this date [3].

3) Medical Applications

As we probably am aware at this point Nikola Tesla investigated himself utilizing a huge amount of voltage produced by Tesla coil's secondary , a perception can be made that high recurrence streams over 10 to 15 kHz did not cause the sentiment an electrical stun/shock. These streams could undoubtedly be gone through a human body without causing hurt. By a few human investigations it was discovered that power signals made by Tesla coil if connected day by day could help mitigating gloom. The warming impacts of these streams were additionally utilized as the base for Diathermy for different joints like elbow and knees. The Paul Marie Oudin influenced adjustments to existing Tesla coil which was later known as Oudin's Coil for the treatment of diabetes, treatment of malignancy, diathermy and so on [3].

4) Show business

The high recurrence safe ebbs and flows and eye getting streamer releases and starts drove the utilization of Tesla coils in the realm of diversion business. Voyaging jamborees and carnival's monstrosity appears, side shows and so on utilized the Tesla coil to catch the concentration of the watchers and indicated how current flashes escaped their body parts. Additionally the sci-fi films likewise began to utilize this which additionally added to prevalence of the Tesla coils and motion pictures too[3].

5) Education

As part of studies from basic middle school to colleges and research stations the Tesla Transformer have always been a part of interest. At school level students prepare this as a part of their mini projects, in which the whole structure is placed in a globe of glass and whenever the glass is touched one can see the lightning streams touching their own finger tips at glass and their hair stands up. So at school level it one of the hot favorite topics of project and a part of fun, while at research stations and college levels it is an extremely important part of High Voltage Engineering field which deals with power system networks, switchgear and their testing, WPT etc.

6) Evacuated system's leak detectors

Tesla transformer's releases are utilized to distinguish the openings in high vacuum frameworks and mechanical assembly. At the point when the framework is cleared the high voltage cathode is moved over the outside surface of device to be checked. On the off-chance that there is a minute gap the power goes through it and crown lights up the opening and henceforth the detection of leakage is hence achievable [23].

7) CRT

Every CRT tube has a small Tesla Transformer called Fly-back Transformer which is used to provide the necessary high voltage to excite and accelerate the electrons emitted from electron gun section toward the picture tube to phosphor screen of the television [23].

8) Vehicles

Oil filled Tesla coil popularly called as the ignition coil IC engine type vehicles which are used to give required high voltage to the spark plug to start the vehicles [3].

Personal Care and Health hazards while Handling Tesla coils

It should never be forgotten that the low voltage primary of the Tesla transformer carries a power supply of 50Hz or 60Hz and thus the currents are lethally dangerous for the operator if carelessness is observed. Also now it is also found that high frequency discharges can also cause the nerve damage and as no pain is felt the experimenters assume that these currents are harmless. If the arcs or discharges touch the bare skin they do cause skin-burns. Even a nominally rated Tesla transformer has the energy to stop the heart of a person or electrocution is also possible 2[7].

Following are the guidelines one needs to take a note for personal care while operating a Tesla Transformer:

1. Check the main power supply and the switchgear. Never leave the assembly of system unattended while power cable is connected with an electrical outlet.
2. Whenever the Tesla coil circuit is turned on, one should never come in contact with any part, or try to assemble or dismantle it. Even if it is turned off, do not attempt to touch it, as it takes some time to completely discharge the coil.
3. As Tesla coil emits large amount long electrical arcs (streams of lightening) , the nearby vicinity of Tesla Transformer has to be kept clear (20 feet or 6 meters) for avoiding unintentional shocks.
4. A separate power supply which is isolated from other main supplies has to be provided because if any other electrical equipment connected to the same supply that of Tesla coil can be damaged.
5. If there is no separate supply then unplug all electrical equipments and then operate Tesla coil.
6. The entire system should be provided with proper electrical earthing.
7. Tesla coils can damage or destroy hearing aids, pacemakers in its proximity. It means that Tesla coils can kill patients with pacemaker/ heart patients. So a person with cardiac diseases must stay away from it.
8. The facilities where Tesla coils are operated, must be properly ventilated and have fire safety equipment as the system produces large amount of heat if overloaded.
9. The arcs from the coil may produce suffocating gases, therefore ventilation must be according to standards.
10. Do not look or observe the internal arcs produced in the assembly itself for long time duration because they are many times brighter than the arcs produced at the outlets. This can damage the vision of any person if not taken care off.
11. Verify that nobody ever comes in contact with low voltage winding of transformer because it is carries high magnitude currents capable killing a person.
12. The facilities employing Tesla Transformer should be moisture, dust free.

Conclusion

The presented review of Tesla coil gives in detail the information regarding various different aspects of its history, development, operation, designing. The paper also discusses important parameters which are taken into consideration for designing any kind of Tesla coil in its basic form. Also the applications and in-depth knowledge of operation, handling, personal care

while operation for the same is also provided. The different works by various authors on this concept has also been presented for the sake of verification and for the readers who are willing to know about Tesla Coils in much more detail. In a nutshell we can say that Tesla transformers themselves have gone through different modifications over considerable time span and hence have found their way through variety of useful concepts, one of most important being the concept of wireless power transfer whose backbone is itself the Tesla coil which is the future of power supply and distribution grids. The current trend is of transmitting D.C. power supply because of its low loss content and higher system efficiency and then back to A.C. supply. The latest and the future scope is of D.C. Tesla Coil which can aid the power grid to generate a wireless, harmonic free, almost loss-less power supply.

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