IMAGE: A MAP OF THE STARS OF THE ORION CONSTELLATION

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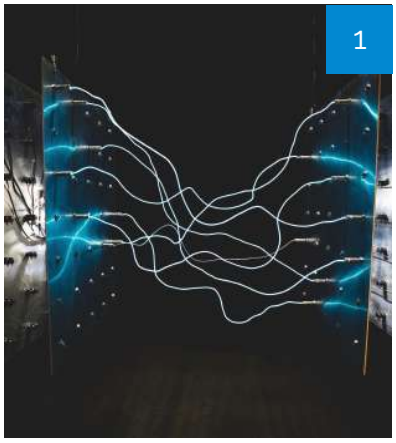

Electric Charge, Substance, Antimatter

Kamliya R.A.

University Abakaliki

ABSTRACT

A new hypothesis was put forward on the coexistence of matter and antimatter in microparticles. This hypothesis about the structure of the electron explains the dualism in the properties of the electron and reveals the nature of electricity. The validity of the hypothesis is shown in the reaction of interaction of an electron with a positron, in the quark structures of mesons and the Higgs boson.

There is a coexistence of opposites on an atomic scale, and therefore the atom is an electrically neutral particle.

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Electric Charge, Substance, Antimatter

Электрический заряд, материя, антиматерия

Kamliya R.A.

Аннотация

В работе выдвинута новая гипотеза о сосуществовании материи и антиматерии в микрочастицах. Выдвинутая гипотеза о структуре электрона объясняет дуализм в свойствах электрона, раскрывает природу электричества. Справедливость гипотезы показана на реакции взаимодействия электрона и позитрона, на кварковых структурах мезонов и бозона Хиггса.

Имеет место сосуществование противоположностей и в масштабах атома и поэтому атом является электронейтральной частицей.

ANNOTATION

A new hypothesis was put forward on the coexistence of matter and antimatter in microparticles. This hypothesis about the structure of the electron explains the dualism in the properties of the electron and reveals the nature of electricity. The validity of the hypothesis is shown in the reaction of interaction of an electron with a positron, in the quark structures of mesons and the Higgs boson.

There is a coexistence of opposites on an atomic scale, and therefore the atom is an electrically neutral particle.

Keywords: matter, antimatter, electron, positron, particle.

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I. Введение

Во все времена главным вопросом естествознания было изучение строения материального мира. После открытия периодической системы элементов атомы считались неделимыми частицами.

В конце XIX века были открыты электроны и свойство радиоактивности некоторых атомов[1]. Далее начались исследования свойств электрона и частиц ядра.

Электроны являются носителями отрицательного заряда и проявляют свойства частицы и волны. Частицы ядра имеют сложную структуру. Масса нейтрона больше массы электрона в 1840 раз. В свободном состоянии нейтроны распадаются на протон, электрон и антинейтрино [1,2].

В ядре существуют сильное и слабое взаимодействия, а нейтроны не распадаются [2].

Исследования нуклонов нацелены на выяснение их структуры. В 60-е годы прошлого века была предложена кварковая структура нейтронов и протонов. Отдельно кварки не существуют. Имеет место конфайнемент кварков. В работах [3,4] дается объяснение природы ядерных сил.

При взаимодействии с другими частицами протоны могут распасться на множество различных микрочастиц. Свойства этих частиц изучаются, но не известно, как они скреплены в нейтроне. В настоящее время известно около 400 микрочастиц [5].

Некоторые частицы являются электронейтральными, а другие заряжены отрицательно или положительно.

Что касается электричества, то оно было открыто задолго до открытия атомов, но его природа тоже не раскрыта до сих пор. Это одна из нерешенных задач, отмеченная в Стандартной модели микрочастиц (СМ).

Мы знаем, что носителем отрицательного заряда является электрон. В атоме отрицательный заряд электронов компенсируется положительным зарядом протонов ядра. Поэтому атом является электронейтральной частицей. Носителем положительного заряда является позитрон, но позитрон является античастицей. Мы говорим, что электрон заряжен отрицательно, позитрон - положительно. Возникает вопрос: существует ли электрон без заряда? Такой частицы не известно.

II. Содержание работы

Прежде чем говорить о новой предлагаемой гипотезе рассмотрим философский аспект вопроса.

Философия, как известно из любой литературы, является наукой о всеобщих законах природы, общества, человеческого мышления. Она обобщает конкретные научные результаты, а обобщенные законы дают новые конкретно-научные результаты. В противном случае незачем обобщать.

Обобщения делаются и в конкретных науках. Так, в физических исследованиях, обобщая экспериментальные результаты, формулируют закон, а этот закон далее используется в теоретических расчетах. От частного к общему, от общего к частному – это методология научного познания.

В философии существует закон единства и борьбы противоположностей. Этот закон справедлив для любой области знаний, в том числе и в материальном мире. Борьба противоположностей имеет место при обеспечении единства противоположностей. Это означает, что противоположности должны находиться рядом. В противном случае нет взаимодействия. Другими словами, противоположности должны сосуществовать и взаимодействовать.

Например, для электрического заряда, чтобы говорить о знаке заряда, должна существовать его противоположность, с которой мы можем сравнивать и судить о знаке заряда.

При определенных условиях сосуществующие противоположности могут взаимно уничтожить друг друга. В этом случае происходит переход к другому объекту с другими противоположностями.

Гипотетически можно предположить, что все частицы, имеющие противоположности, уничтожены взаимодействием противоположностей. После такого взаимного уничтожения не должно остаться избытка материи либо антиматерии, потому что материя либо антиматерия не могут существовать без противоположности. Следовательно, в материальном мире количество материи и антиматерии равны. Имеет место баланс материи и антиматерии.

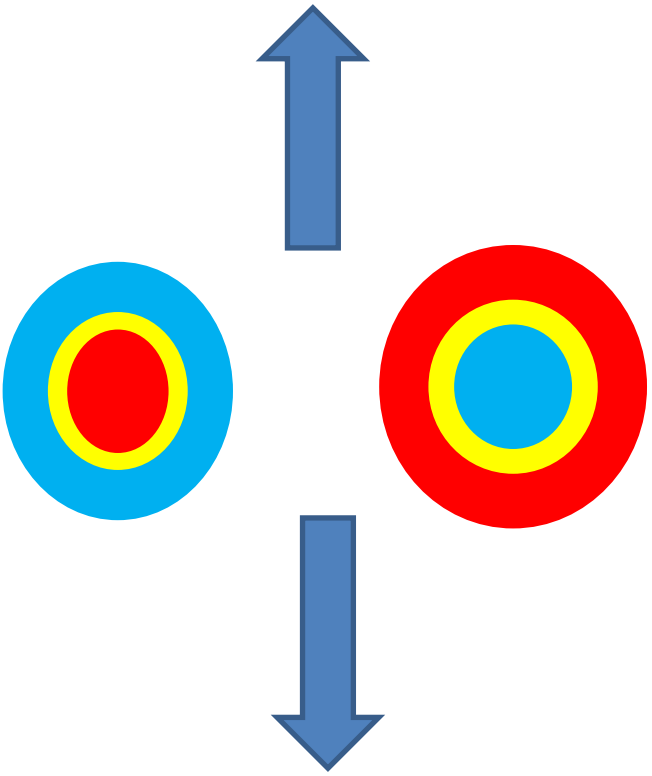
В соответствии с законом единства и борьбы противоположностей, материя и антиматерия должны сосуществовать. Следуя этому положению, смоделируем структуру электрона, в которой материя и антиматерия сосуществуют. Таких вариантов могут быть два.

В первом варианте материя и антиматерия сосуществуют в виде диполя (рис.1*а*). Если мы заменим материю на антиматерию, а антиматерию на материю, то получим частицу тождественную исходной (рис.1*б*). Изменилась только ориентация на 180 градусов.

а) *б*)

Рис.1: Тождественные частицы
а) частица, б) античастица

Второй вариант представляет собой сферическую слоеную структуру, в которой для электрона наружный слой является материей, внутренний – антиматерией. Непосредственного контакта между материей и антиматерией не может быть потому, что в этом случае произойдет аннигиляция материи и антиматерии. Поэтому остается предположить, что между материей и антиматерией имеется прослойка эфира, которая в какой-то мере сдерживает аннигиляцию (рис.2*а*). Если в структуре электрона заменить материю (внешний слой) на антиматерию, а антиматерию (внутренний слой) на материю, получим антиэлектрон (позитрон) (рис.2*б*), имеющий положительный заряд такой же величины что и электрон.



а) *б*)

а) электрон. б) позитрон

Рис.2: Аннигиляция электрона с позитроном

В соответствии с законом Кулона электрон и позитрон, имеющие противоположные заряды, притягиваются друг другу. Электрон и позитрон являются противоположностями в смысле электрического заряда, а их внешние слои тоже являются противоположностями в смысле материи и антиматерии. Внутренние слои электрона и позитрона также являются противоположностями. Свойство заряженности придают внешние слои, а действие внутренних слоев экранируется внешними слоями.

Не правильно говорить, что электрон заряжен отрицательно. Не бывает незаряженного электрона. Электрон, имеющий сферическую слоеную структуру, состоящую из материи и антиматерии (рис.2*а)*, является зарядом.

Именно потому, что электрон и позитрон, имеющие вышеописанную структуру, при взаимодействии излучают два гамма-кванта. Один гамма- квант излучается при взаимодействии внешних слоев, а второй гамма-квант – при взаимодействии внутренних слоев. Если бы структуры электрона и позитрона были бы цельными, то результатом их взаимодействия был бы один гамма-квант.
Как известно электрон при некоторых условиях проявляет свойства волны. Это происходит потому, что оказалось возможным аннигиляция внутреннего и наружного слоев. Причина дуализма в свойствах электрона становится понятной.

Замена материи на антиматерию и наоборот приводит в структурах электрона и позитрона к изменению знака заряда. Можно написать

$$\bar{e} = p \qquad (1)$$

где: *e*–электрон,

$\bar{e}$ -антиэлектрон(инверсия электрона),

p – позитрон.

Инверсия электрона означает замена материи на антиматерию и наоборот. Мы в этом случае получаем антиэлектрон (позитрон), который подчиняется тем же законам, что и электрон, но является античастицей. При таком преобразовании изменяется и электрический заряд на противоположную полярность, но подчиняется тем же электрическим законам. На языке теории симметрии это называется инвариантностью к преобразованиям, в данном случае к преобразованиям вида материя-антиматерия. В нашем случае происходит одновременно преобразование вида положительный заряд - отрицательный заряд и преобразование вида материя-антиматерия.

Электрон является элементарной частицей. Соблюдается ли закономерность для других частиц, которые содержат множество элементарных частиц?

Чтобы получить античастицу следует произвести инверсию всех его компонентов. При этом должны измениться все заряды на противоположную полярность, а следовательно суммарный заряд тоже должен измениться на противоположную полярность. Если частица электронейтральная, то она остается электронейтральной.

Вообще любая частица, в том числе и нуклоны, есть смесь материи и антиматерии и в то же время является смесью положительного и отрицательного зарядов. Об этом свидетельствуют результаты распада, например, нейтрона. Он испускает антиматерию (антинейтрино) и отрицательный заряд электрона, а остается протон с положительным зарядом.

Инверсия всех компонентов нейтрона даст нам антинейтрон. Точно таким же образом получаются антикварки из кварков.

Теперь проанализируем кварковый состав мезонов, структуры которых известны (таблица 1). Черточка сверху названия кварка означает инверсию (антикварк). Инверсия антикварка дает кварк.

Как видно из таблицы 1, для изменения знака заряда мезона следует инвертировать оба кварка, входящих в мезон. Закономерность соблюдается для всех мезонов независимо от кваркового состава. Преобразования вида материя - антиматерия тождественны преобразованию вида положительный заряд-отрицательный заряд.

Таблица1

Обозначение Мезона	π^+	π^-	K^-	K^-	K^0	$\overline{K}^0$	D^+	D^-	D_s^+	D_s^-	B^+	B^-
Кварковая структура	$u\bar{d}$	$\bar{u}d$	$u\bar{s}$	$\bar{u}s$	$d\bar{s}$	$\bar{d}s$	$c\bar{d}$	$\bar{c}d$	$c\bar{s}$	$\bar{c}s$	$u\bar{b}$	$\bar{u}b$

Определенный заряд кварка означает, что в нем какого-то заряда содержится в большем количестве, чем заряда противоположного знака. Если во всех частицах произведем инверсию материи и антиматерии, то из мезона получится антимезон, а знак заряда изменится на противоположный знак. Эту закономерность мы и наблюдаем в таблице 1.

Таким образом, электрического заряда как такового не существует. Материю и антиматерию, которые взаимодействуют между собой, мы воспринимали как отрицательный и положительный заряды. Электрический заряд нигде не проявляется.

Наши рассуждения хорошо демонстрируются при распаде бозона Хиггса. Бозон Хиггса имеет кварковую структуру H= $b\bar{b}$ –это совокупность *b*-кварка и анти *b*-кварка. Как мы уже говорили, $\bar{b}$ -кварк является инверсией *b*-кварка. Именно поэтому при распаде бозона Хиггса получаем пары частиц с античастицами – электрон-позитронная, мюон-антимюонная. Излучение двух фотонов свидетельствует о взаимном уничтожении (аннигиляции) частицы с античастицей, имеющих структуру, в которой материя и антиматерия сосуществуют.

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III. Заключение

Гипотеза о сосуществовании материи и антиматерии объясняет природу дуализма в свойствах электрона, природу электричества, не противоречит физическим законам и согласуется с философией. Философский закон единства и борьбы противоположностей требует обеспечения единства противоположностей и в материальном мире тоже. В противном случае нет борьбы противоположностей.

Сделанное заключение подтверждается результатом взаимодействия электрона и позитрона, кварковой структурой мезонов, структурой и результатом распада бозона Хиггса.

IV. Выводы

1. В микрочастицах материя и антиматерия сосуществуют.
2. Электрического заряда не существует.

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An Innovative Structural Method to Implement Earthquake-Resistant Buildings

Ramy Morsy Elkholy

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ABSTRACT

With the amazing development in all fields of science and with the rapid progress in building technology and the increasing need for more effective construction implementation methods in resisting stresses on concrete structures, this construction method has been developed to give a structural advantage to high-rise buildings in resisting earthquake loads.

Keywords: lateral loads, seismic loads.

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Keywords: lateral loads, seismic loads.

Author: Faculty of Engineering El-Mansoura University, Egypt

I. INTRODUCTION

Regular structural buildings consist of a number of elements (foundations , columns , beams , slabs , filling walls).

Columns and beams are an important component exposed for resisting loads and structural stresses , so it is important to increase the stiffness of the points of contact between the columns and next columns in all floors of building, as well as between columns and beams.

Of engineered known that the greater the height of structure increased exposure to lateral loads.

The column- beam joints and the contact joint between column and the column in next floor are the prominent joints exposed to seismic loads in structure.

Strong column – weak beam joint is important concept in resist seismic loads.

This paper is devoted to increase resist of structure by increase effectiveness and resistance of the columns joints.

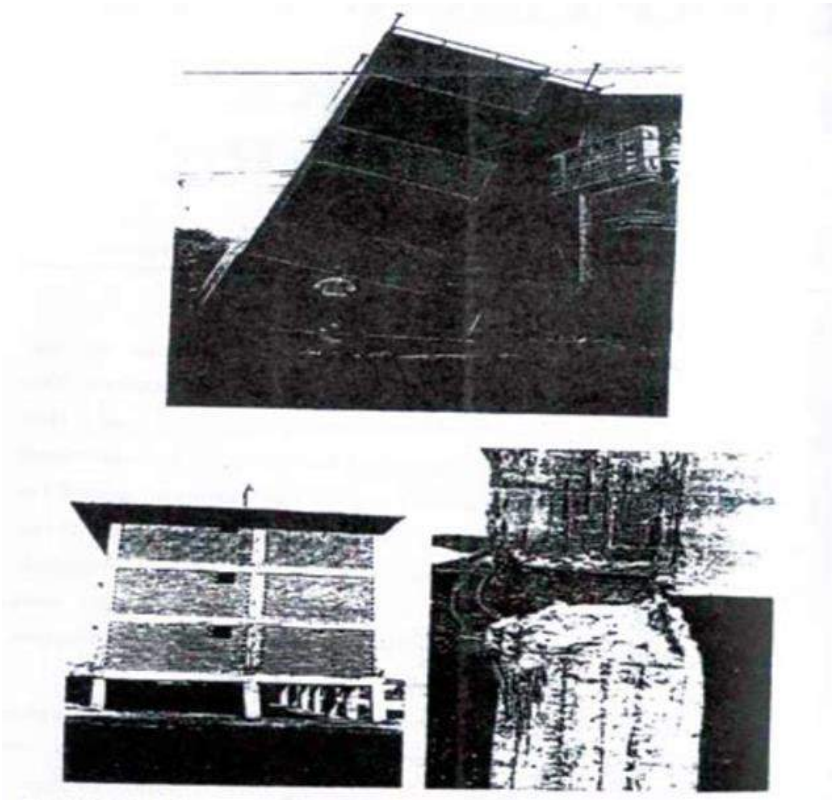


Fig. (1.1): Photographs of damage caused by earthquakes

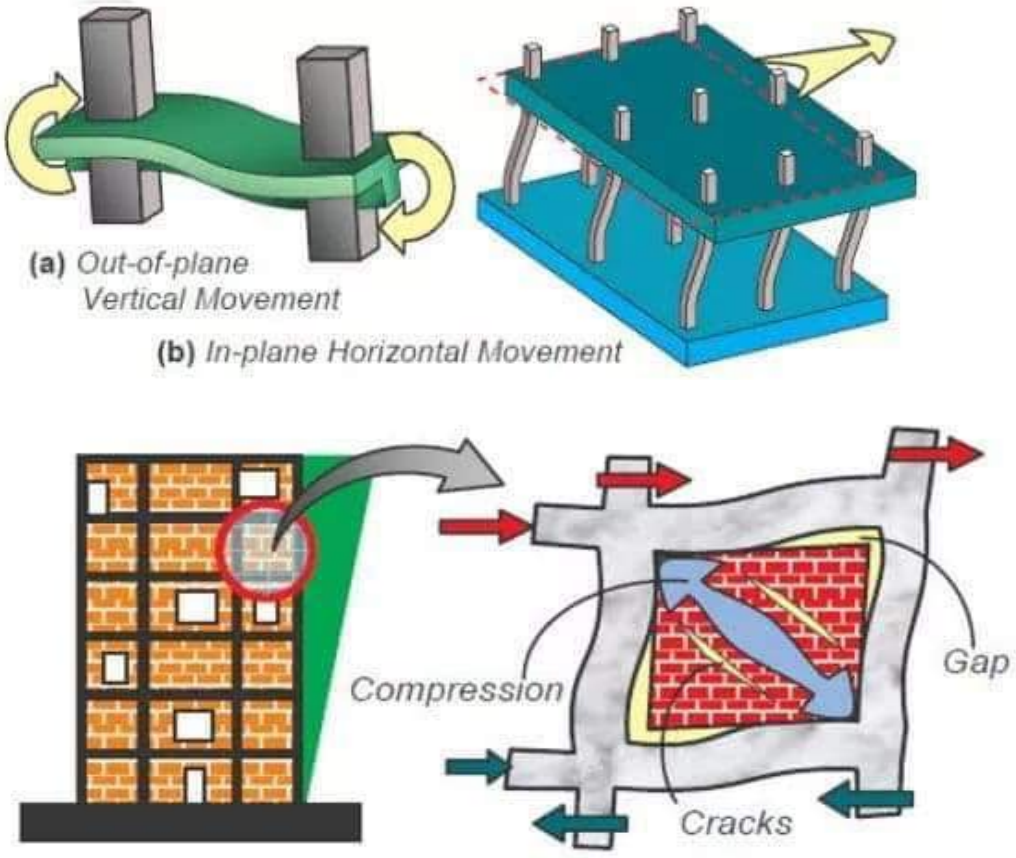


Fig. (1.2): Behavior of elements of building under seismic loads

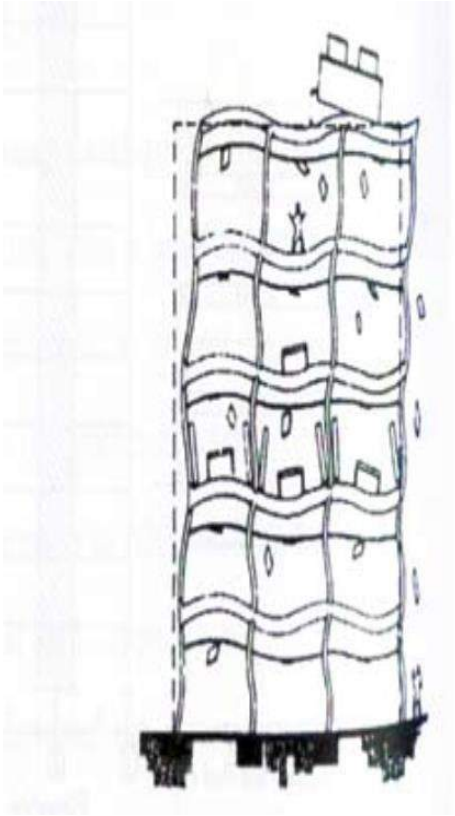


Fig. (1.3): Columns behave separately not as a group action

II. THE THEORY

By studying the behavior of reinforced concrete structures under the influence of earthquakes, we find that the stresses are concentrated on the points of contact of the columns with the beams and slabs, so if the stress occurred above the limit borne by the reinforced concrete, collapse will occurs usually in columns as shown in fig. (1.1) , In fact the contact points of the columns are exposed to forces resulting from the horizontal displacement that is formed in each level of building and effective on beams and large areas slabs in each floor as shown fig. (1.2).

The elements of building behave separately, due to the nature of their implementation in reality, where the elements of each floor were poured, and then the elements of the next floor were poured, and so on and the way to connect this elements of the buildings is with the property of adhesion of concrete and Coherence length in steel bars(ld) as shown fig.(1.3) .

But if we want to increase the efficiency and resistance of the joints of concrete structures, a method must be devised to implement the elements of concrete structure to give behavior when exposed to earthquake forces as if these elements were poured into the site once as one unit as columns located on a vertical axis behave as a group action and this is what this research provides.

For example a building consisting of 30 floors with a height of one floor 3.0 meters on a single vertical axis there are 30 columns with a height of 3.0 meters for each column. The column for each floor was poured separately then the beams and the slab of this floor before moving to the next floor column and so on. This gives separate behavior for each column and generates a different amount of displacement in Each floor, and this certainly differs, if you represented 30 columns as one column extending from the beginning of the structure to the end with total length 90 .0 meters, this is called (columns group action).

It is common in construction sites the pouring of concrete columns for each floor separately, the cohesion between columns one top of each for multiple stories structure by extension of steel bars mostly does not exceed 1.0 meter, so full height column of structure can be represented as a group of units of columns pouring one top of each, this may not represent a problem for low- rise structures but for sure represent a problem for high- rise structures especially when structure exposed to seismic loads.

The purpose of study to make each vertical group of columns to behave as one unit as if columns have poured once building length.

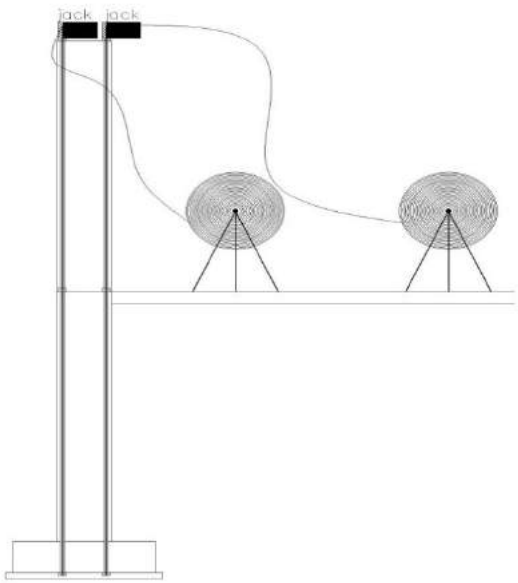
III. PRACTICAL APPLICATION

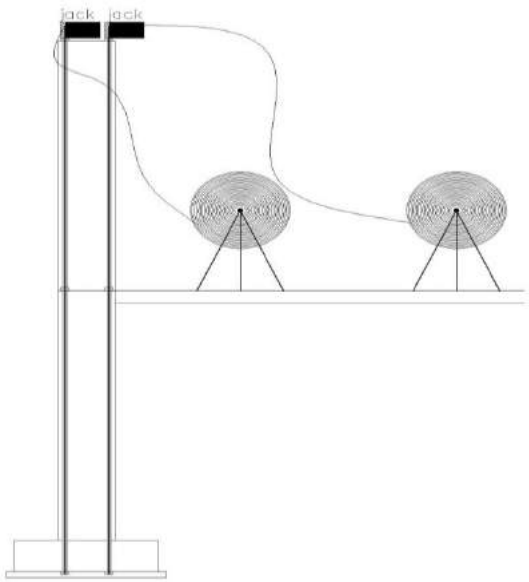
In addition to main reinforcement of the columns with steel bars in this technique we will increase the reinforcement with steel cables that will be installed in the foundations and continue along the column until the end of the structure, These cables will be affected by a central tensile force using hydraulic jacks as used in prestressed concrete, to keep the steel cables under the tensile effect until Concrete hardens, and this process is repeated for the columns of each floor until the end of the building, so that the columns of each vertical group of columns are connected to each other with the same tensile strength, which gives structural behavior as well as that the column was poured into its entire length once. pouring columns under axial force by hydraulic jacks that will retain until concrete hardening by using hydraulic jacks then will pouring next floor columns under the same axial load that will retain until concrete hardening and repeat the same steps for each floor columns .

The cables used should be continuous full length of columns by using rolls of cables and installed in foundation steel bars.

The cables rolls should be moved from floor for the floor who followed with continuity of cables.

Finally structure columns will be subjected to the same axial load full height of the building and every vertical row of columns will behave as one column.





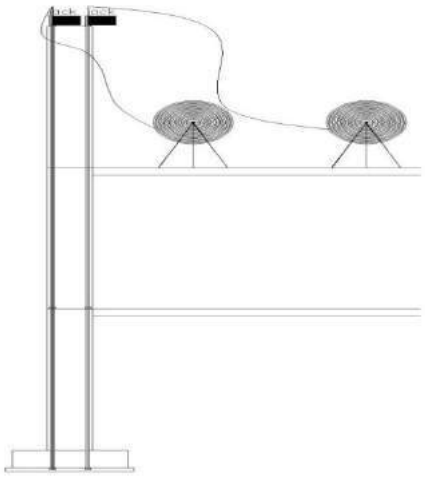


Fig. (1.4): Steps of Implementation in the site

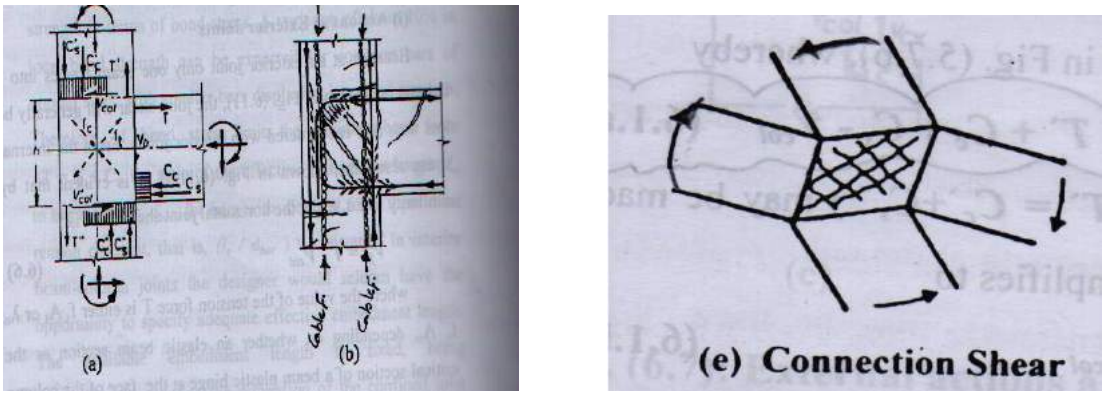
Fig (1.5): Shapes of hydraulic jacks

IV. MATHEMATICAL ACHIEVEMENT

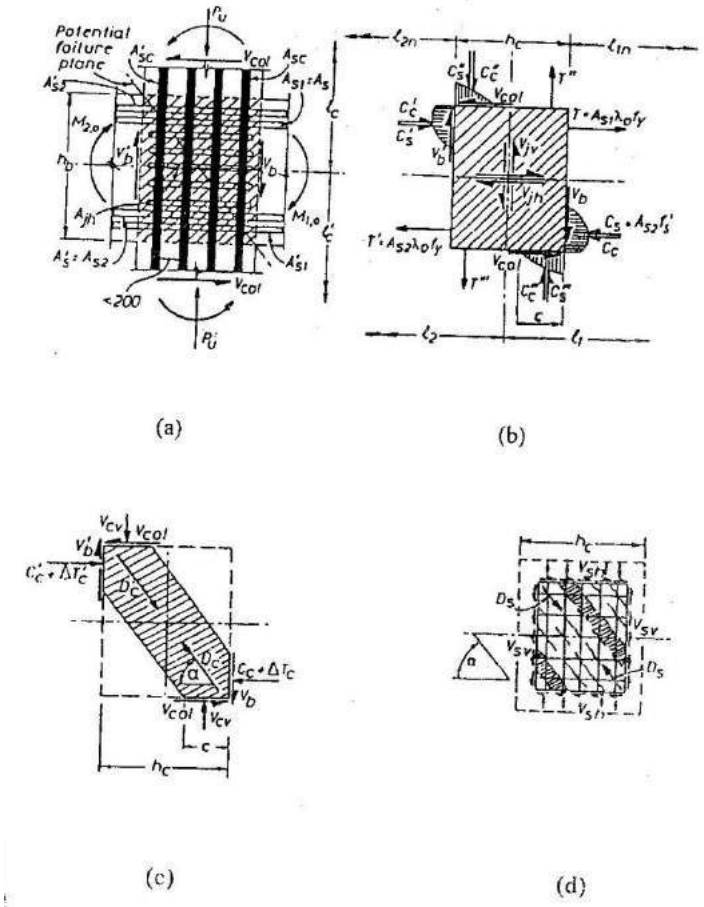
It is now generally recognized that beam – column joints can be critical regions in reinforced concrete frames can be critical regions in reinforced concrete frames designed for in elastic response to seismic attack .

As a consequence of seismic moments in columns of opposite signs immediately above and below the joint , and similar beam moment reversal across the joint.

The Joint region is subjected to horizontal and vertical shear forces.



Fig(1.6): Analysis forces resultants at Internal (Beam – Column joint)



Fig(1.6): Analysis forces resultants at Internal (Beam – Column joint)

Vjh= T + Cc +Cs – Vcol. = T+ Cc + Cs-Vcol.

(T=Cc + Cs)

Vjh= T +T -Vcol.

Vjv = T + T –Pu/2-Vb- Fc (Fc = Cable force)

When we use this new technique in pouring columns we will generated new force is called Cable force (Fc) which is reduced shear forces on column – beam Joint and by controlling(Fc) we can prevented a chance to joint shear failure.

V. CONCLUSION

The study will achieve important principle (strong column- column) joint

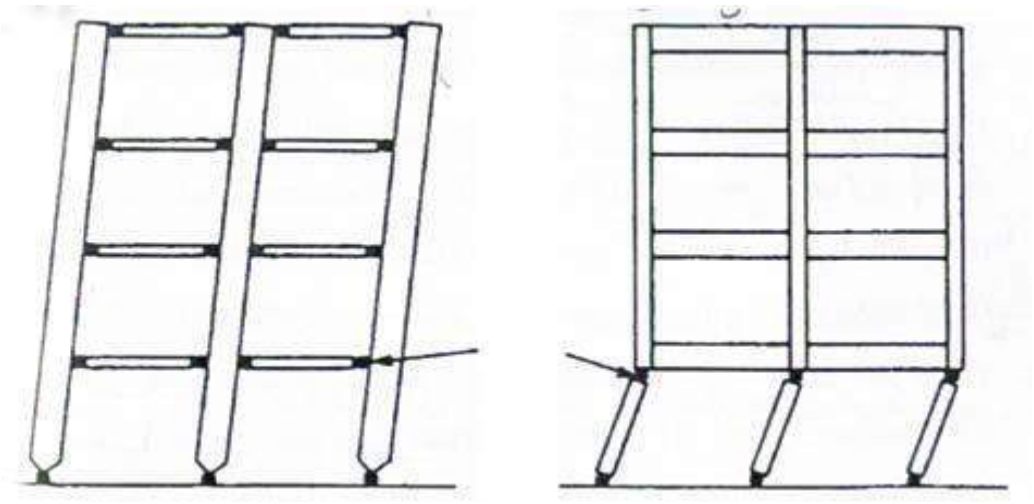


Fig.(1.7) : The effect of the system to increase resist of buildings to seismic loads

Fig. (1.7) show the effect of the suggested system to resist seismic loads , in the structure on the left columns behave as one unit .

Structure on the right where the normal method in building are used additional stresses are generated in earthquakes.

VI. FINALLY

The system can be used in high rise reinforced concrete buildings, cable suspended bridges with large spans.

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Review: General Principles on the Solid Body Astrodynamics

Viorel-Mihai Nani & Alin Nani

ABSTRACT

The paper presents the theoretical foundation of the dynamics of the solid body in gravitational movement in outer space. It is known that the movement of solid bodies in space is subject to both the laws of Newton's classical mechanics and those of Kepler's celestial mechanics. Thus, the necessary conditions whom a solid body must fulfill to be able to leave the terrestrial surface and be launched into space are established. Also, the parameters that define the trajectories that solid bodies can have in the gravitational field are presented.

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The paper presents the theoretical foundation of the dynamics of the solid body in gravitational movement in outer space. It is known that the movement of solid bodies in space is subject to both the laws of Newton's classical mechanics and those of Kepler's celestial mechanics. Thus, the necessary conditions whom a solid body must fulfill to be able to leave the terrestrial surface and be launched into space are established. Also, the parameters that define the trajectories that solid bodies can have in the gravitational field are presented.

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I. INTRODUCTION TO ASTRODYNAMICS

Orbital mechanics or *astrodynamics* is the application of ballistics and celestial mechanics to the practical problems concerning the motion of solid bodies in space, as the rockets, artificial satellites and spacecraft [1-3]. The movement of these bodies is usually calculated using laws taken from classical mechanics: Newton's law of motion and universal gravitation law. Orbital mechanics is a basic discipline that allows the design and control of the space mission. It treats more the orbital dynamics of solid bodies under the influence of gravity, including spacecraft as well as natural astronomical bodies such as star systems, planets, natural satellites and comets. The orbital mechanics focuses on spacecraft trajectories, including orbital maneuvers, changes in orbit, and interplanetary transfers, and is used by mission planners to predict the results of propulsive maneuvers. General relativity is a more accurate theory than Newton's laws for calculating orbits, and sometimes is required for greater computational accuracy or in high gravity situations (such as the orbits of planets closer to the Sun) [4].

II. PRINCIPLES AND TECHNIQUES APPLIED IN ASTRODYNAMICS

The following principles and techniques contained in a compendium of applicative rules are useful for approximated situations by classical mechanics in accordance with standard assumptions formulated in astrodynamics. The most specific and frequent case for analysis is that of a satellite that orbits a planet, but these rules could apply to other situations, such as orbits of small solid bodies around a star such as the Sun. Thus [5]:

- Kepler's laws on the planetary motion:
- The orbits are elliptical, with the heavier body placed in one of the ellipse focus points. Particularly: Orbit has a circular trajectory, where the circle is a special case of the ellipse, and the planet is located in the system center.
- A line drawn from the planet to the satellite measures equal areas in equal time, regardless of the measured orbit portion.
- The square of the orbital period of a satellite is proportional to the cube of the mean distance from the planet.
- Without applying an external force, such as the firing force emitted by a rocket engine, the period and shape of the satellite's orbit will not change.

- A satellite that gravities on a low orbit or on the low part of an elliptical orbit, moves faster than the planet's reference surface relative to another satellite that revolves over a larger orbit or on the higher part of an elliptical orbit, due to higher gravitational field of the satellite located closer to the planet.
- If the external force is applied only in one point from the satellite orbit, the satellite will return to the same point on each subsequent orbit, although its trajectories will always change. Consequently, one cannot move from one circular orbit to another with a single brief application of a thrust pulse.
- If to one satellite placed on a circular orbit was applied a thrust pulse in a direction opposite to motion, then its trajectory changes into an elliptical orbit, and the satellite will descend and reach the lowest orbital point called periapsis, located to 180° away from the firing point, after which it will ascend back to the initial impulse point. If the satellite receives a traction impulse in the direction of motion, then its trajectory changes into an elliptical orbit, but the satellite will climb to the highest point of the trajectory, called apoapsis, located to 180° away from the firing point, after which it will descend back to the initial impulse point.

III. LAWS OF ASTRODYNAMICS

The fundamental laws of astrodynamics, as was outlined in paragraph 1, are Newton's universal gravity law and the motion laws of solid bodies enunciated by Newton, and the mathematical solution of these laws is based exclusively on differential calculus [1, 2].

The first equation of motion is:

$$F = ma \tag{1}$$

where: $\boldsymbol{F}$ is force [N], $\boldsymbol{m}$ is mass [kg] and $\boldsymbol{a}$ is acceleration [m/s²]
The Earth creates a gravitational field $\boldsymbol{E(r)}$ given by:

$$E(r) = \frac{Gm_E}{r^2}\vec{r} \tag{2}$$

where: $\boldsymbol{m_E} = 5.972\times10^{24}$ kg is a constant value and represents the mass of the Earth, $\boldsymbol{G} = 6.674\times10^{-11}$ N·m²/kg² is the gravitational constant, $\boldsymbol{r}$ is the distance from Earth to solid body (satellite) [m] that gravitates around the Earth, and $\vec{r}$ is the vector of this distance (the derivative by the first order of this distance is velocity) [m/s]).

The gravitational force acting on the solid body in motion is equal to:

$$F_{cp} = -\frac{Gm_E m\vec{r}}{r^2} = -\frac{Gm_E mr}{r^3} \tag{3}$$

This force acts inwardly, i.e. to the Earth. For this reason it is defined as a centripetal force acting on the solid body. Since the product Gm_E is a constant, it can be defined

$$\mu = Gm_E = 3.986\,x10^{14}\ Nm^2/kg$$

which is known in the literature as *Kepler's constant*. By entering the above value in relation (3), it is obtain:

$$F_{cp} = -\frac{\mu mr}{r^3} \tag{4}$$

In order to maintain the solid body on a well-defined trajectory, simultaneously acts on it an $\boldsymbol{F_{cf}}$ centrifugal force, equal and opposite to the $\boldsymbol{F_{cp}}$ centripetal force. The balance of these two forces makes the solid body move on a certain trajectory without falling into the center of mass **O**. The dynamics of these two forces is illustrated in Figure 1.

If points **A** and **B** are very close, then:

$$\frac{\overline{AB}}{\overline{OA}} = \frac{vdt}{r} \approx \frac{dv}{v} \tag{5}$$

Knowing:

$$\frac{dv}{dt} = \frac{v^2}{r} \tag{6}$$

the centrifugal force of the solid body is given by:

$$F_{cf} = m\frac{dv}{dt} = m\frac{v^2}{r} = \frac{mv^2\vec{r}}{r} = \frac{mv^2 r}{r^2} \tag{7}$$

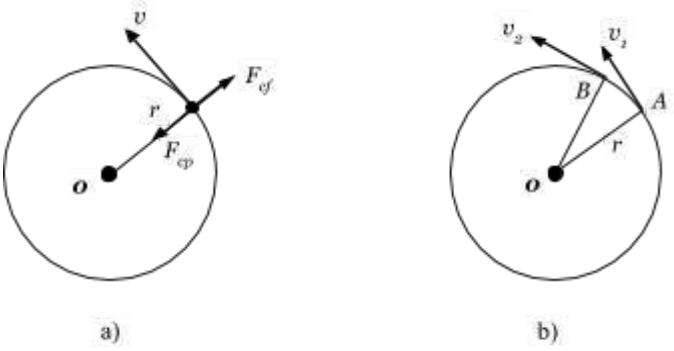

Figure 1
a) forces acting on the solid body
b) vectors velocity at two different moments

Since the sum of the forces acting on the solid body must be zero, from equality of relations (4) and (7) results in:

$$\frac{\mu m}{r^2} = \frac{mv^2}{r} \quad \Rightarrow \quad v = \sqrt{\frac{\mu}{r}} \qquad (8)$$

A direct consequence of this equation is that the velocity of the solid body is inversely proportional to its orbital altitude ***r***. The lower the orbit of the solid body, the faster it travels in space. To determine the length of time ***T*** needed for a solid body to go through a particular orbit, must calculate the circumference ***S*** of that orbit:

$$T = \frac{S}{v} = \frac{2\pi r}{\sqrt{\frac{\mu}{r}}} = 2\pi r\sqrt{\frac{r}{\mu}} \qquad (9)$$

It can be noticed that the higher the orbital altitude ***r*** of a solid body, the longer its orbital period. The orbit of a solid (satellite) body can be graded according to the corresponding orbital altitude and period, as shown in Table 1.

Table 1

Orbit	Orbital altitude /km/	Orbital period T
Low Earth Orbit	160 – 2 000	87 – 127 min
Medium Earth Orbit	2 000 – 35 786	127 min – 24 hr
Geostationary Earth Orbit	35 786	23 hr 56 min 4.1 sec

Any orbit and trajectory outside the terrestrial atmosphere is, in principle, reversible, i.e. in the space-time coordinate system, the time parameter is reversed. The displacement velocities are also reversed, while the accelerations remain the same, including those due to the bursts of the rocket engines. Thus, if a burst of the rocket engine creates an impulse in the direction of the velocity, according to the reversibility principle, it opposes velocity. Of course, in the case of rocket engines explosions, there is no complete reversibility of the events, although in both cases the same differential calculation of the velocity and the same mass ratio applies.

Some standard assumptions have been adopted in astrodynamics, which refer to non-interference from the outside solid bodies, negligible mass for one of the bodies, and the neglect of insignificant forces such as solar wind, atmospheric drag, etc. More accurate calculations can be made without these simplifying hypotheses, but they are more complicated. Increased accuracy often does not make enough difference in the calculation to be useful.

Kepler's laws on planetary motion can be derived from Newton's laws when it is assumed that only the gravitational force of the central solid body acts on the solid (satellite) body which is in orbital motion. When a thrust force or propulsion force is present, Newton's laws continue to apply, but Kepler's laws are invalidated and are not applicable. When the thrust force or propulsion force ceases, the resulting orbit will be different from the original one, but it will again be described by Kepler's laws. The three laws on our solar system are:

The orbit of a smaller solid body relative to another larger solid body is always an ellipse with the center of mass located in the larger solid body, in one of the two focus points of the ellipse. In other words, the orbit of any planet is an ellipse with the sun placed in one of the outbreaks.

The orbit of the smaller solid body measures equal areas in an equal amount of time. That is, a line joining a planet and the sun sweeping equal areas in equal time intervals.

The squares of the orbital periods of the smaller solid body are directly proportional to the 3rd power of the semi-major axis of the orbits multiplied by a constant.

IV. ESCAPE VELOCITY

Escape velocity v_e is the slowest velocity a solid body has to have to escape the gravitational attraction of a certain planet or other heavier solid body. If the solid body slows at a minimal orbital velocity, it will hit the planet; if it accelerates beyond the maximum escape velocity, it will be permanently removed from the planet [6]

The formula for calculating an escape velocity is easily derived as follows. The specific energy (energy per unit mass), called $\boldsymbol{\varepsilon}$, of any spacecraft is composed of two components, the specific potential energy $\boldsymbol{\varepsilon_p}$ and the specific kinetic energy $\boldsymbol{\varepsilon_k}$. The specific potential energy of the solid body associated with a planet of mass $\boldsymbol{M}$, having the gravitational acceleration $\boldsymbol{G}$ and located at distance $\boldsymbol{r}$, is given by:

$$\varepsilon_p = -\frac{GM}{r} \tag{10}$$

while specific kinetic energy to same solid body is given by:

$$\varepsilon_k = \frac{v_e^2}{2} \tag{11}$$

By applying the law of energy conservation:

$$\varepsilon = \varepsilon_k + \varepsilon_p \tag{12}$$

and so the total specific orbital energy, is obtained:

$$\varepsilon = \frac{v_e^2}{2} - \frac{GM}{r} \tag{13}$$

which does not depend on the distance $\boldsymbol{r}$ from the center of the planet, i.e. the central solid body, to the space vehicle in question. Therefore, the space vehicle can reach infinite $\boldsymbol{r}$ only if the escape velocity is not negative. In the case where $\boldsymbol{\varepsilon = 0}$, the escape velocity must fulfill the condition:

$$v_e \geq \sqrt{\frac{2GM}{r}} \tag{14}$$

For information, the escape velocity on the Earth's surface is about 11 km/s, but this is insufficient to send the solid body (space vehicle) to an infinite distance due to the gravitational attraction of the Sun. To escape from the Solar System from a location situated at a certain distance from the Sun, equal to the Sun-Earth distance but not close to Earth, a velocity of about 42 km/s is required. If a space vehicle is launched in the displacement direction of the Earth, which is in its orbital motion around the Sun, acceleration due to its own propulsion system requires much lower values.

V. ORBITAL VELOCITY

According to standard simplification assumptions, *the orbital velocity* v_o of a solid body moving along an elliptical orbit, can be calculated with equation [4, 6]:

$$v_o = \pm\sqrt{\mu\left(\frac{2}{r} - \frac{1}{a}\right)} \tag{15}$$

where: $\boldsymbol{\mu}$ is the standard gravitational para meter [Nm²/kg], $\boldsymbol{r}$ is the distance between the orbital solid bodies [m] and $\boldsymbol{a}$ is the length of the major semi-axis [m].

In the case of a hyperbolic trajectory, the orbital velocity of the solid body may have a positive or negative value depending on the conventional sense of movement of the solid body on its orbit.

VI. ORBITAL SPECIFIC ENERGY

In the case of standard simplifying assumptions, the orbital specific energy $\boldsymbol{\varepsilon}$ of a solid body gravitating on an elliptical orbit is negative, and the orbital equation for orbital energy conservation corresponding to this orbit, can take the form [3]:

$$\frac{v_o^2}{2} - \frac{\mu}{r} = -\frac{\mu}{2a} = \varepsilon < 0 \tag{16}$$

where: $\boldsymbol{v}$ is the velocity of the orbiting solid body [m/s], $\boldsymbol{r}$ is the distance between the orbiting solid body and the gravity center of the central body [m], $\boldsymbol{a}$ is the length of the major semi-axis [m], $\boldsymbol{\mu}$ is the standard gravitational parameter [Nm²/kg].

For a given major semi-axis, the specific orbital energy is independent of the magnitude of the eccentricity. In some particular cases:

- The mean value of the specific potential energy ε_p is equal to 2ε
- The mean value of the distance r^{-1} is equal to a^{-1}
- The mean value of the specific kinetic energy ε_k is equal to $-\varepsilon$

VII. CALCULATING TRAJECTORIES. KEPLER'S EQUATION

A way of calculating the trajectories of solid bodies, viewed from the perspective of a historical approach, is based exclusively on Kepler's equation:

$$M_a = E_a - e.sinE_a \qquad (17)$$

where: M_a is the mean anomaly [m], E_a is the eccentric anomaly [m], and e is the eccentricity [m].

With Kepler's formula it is possible to determine the time-of-flight of the solid body to reach the value o of the periapsis angle, which is the true anomaly. The calculation procedure comprises two steps [7]:

1. Determination of eccentric anomaly E_a from true anomaly o
2. Determination the time-of-flight at time t against eccentric anomaly E_a

Finding the eccentric anomaly at a given time (the inverse problem) is more difficult. Ecuaţia lui Kepler's equation is transcendental in E_a, which means it cannot be solved algebraically. Determination of the eccentric anomaly E_a from the Kepler's equation can be done by analytical way, by inversion.

A solution of Kepler's equation, valid for all real values of e is [8]:

$$E_a = \{\sum_{n=1}^{\infty} \frac{M_a^n}{n!}\left(\frac{d^{n-1}}{d\theta^{n-1}}\left(\frac{\theta}{\sqrt[3]{\theta - sin(\theta)}}\right)^n\right) \quad \varepsilon = 1 \quad \sum_{n=1}^{\infty} \frac{M_a^n}{n!} \varepsilon \neq 1 \qquad (18)$$

By developing these relationships, it is obtain:

$$E_a = \{x + \frac{1}{60}x^3 + \frac{1}{1400}x^5 + \frac{1}{25200}x^7 + \frac{43}{17248000}x^9 + \frac{1213}{7207200000}x^{11} \ldots$$

$$|x = (6M_a)^{\frac{1}{3}}, \quad \varepsilon = 1 \quad \frac{1}{1-\varepsilon}M_a - \frac{\varepsilon}{(1-\varepsilon)^4}\frac{M_a^3}{3!} + \frac{(9\varepsilon^2+\varepsilon)}{(1-\varepsilon)^7}\frac{M_a^5}{5!} - \frac{(225\varepsilon^3+54\varepsilon^2+\varepsilon)}{(1-\varepsilon)^{10}} \qquad (19)$$

Alternatively, Kepler's equation can be solved and numerically. Initially, an arbitrary value is assigned to it and the time-of-flight is calculated, then are given more consecutive values E_a, as much as needed to bring the calculated time-of-flight closer to the desired value until the required precision is obtained. Typically, Newton's method is used to achieve relatively rapid convergence.

The main difficulty with this approach is that it may take too long to achieve a satisfactory convergence of extreme elliptical orbits. For almost-parabolic orbits, eccentricity e is close to value 1. Entering this value ($e = 1$) into the formula for mean anomaly ($E_a - e.sinE_a$) shows that two almost equal values are subtracted and the accuracy suffers. For almost-circular orbits it is difficult to determine the periapsis, because the truly circular orbits have no periapsis at all. In addition, the equation was derived from the hypothesis of an elliptical orbit, and so it is not valid for parabolic or hyperbolic orbits.

VIII. GRAVITY AND THE OBERTH' EFFECT

In a known and controlled gravitational field, a spacecraft located in the atmosphere of a planet, can leaves it and go in a different direction at a different velocity [7]. This is useful to accelerate or slow a spacecraft, avoiding the transport of a surplus fuel.

This maneuver can be approximated by an elastic collision at great distances, although the change of flight coordinates does not involve any physical contact. Due to Newton's third law (the principle of action and reaction, according to which reaction is equal to and opposite to action), any impulse gained by a spacecraft must be lost relative to the planet or vice versa. However, because the planet is much, much more massive

than the spacecraft, its effect on the planet's orbit is negligible [9].

The Oberth' effect, in which a rocket engine generates more energy when traveling at high speed than if it is constantly traveling at a lower speed, can be used especially during a gravity assistance operation. The Oberth effect can be employed, particularly during a gravity assist operation. This effect consists in the fact that the use of a propulsion system works better at high speeds and therefore the course changes are best performed when they are close to a gravitational solid body. This can lead to the multiplication of the effective velocity derivative, i.e. the acceleration.

IX. CONIC SECTIONS

By *conic section* is meant a curve resulting from the intersection of a plane with a straight circular cone [8]. As shown in Figure 2, the angular orientation of the plane with respect to the cone determines whether the conical section is a circle, an ellipse, a parabola, or a hyperbola. *The circle and ellipse* occur when the intersection between the cone and the plane is a bounded or closed curve. The circle is a special case of the ellipse when the plane is perpendicular to the axis of the cone. If the plane is parallel to the cone generator line, then an open curve is obtained called a *parabola*. Also, if the intersection is an unlimited curve and the plane is parallel to the cone axis or it's not parallel to the cone generator line, then this is a *hyperbola*. In the latter case, the plane will intersect both halves of the cone, producing two separate curves.

Table 2

Conic section	Eccentricity, e	Semi-axis major	Energy
Circle	0	radius	<0
Ellipse	0<ε<1	>0	<0
Parabola	1	infinity	0
Hyperbola	>1	<0	>0

The type of conical sections can be defined in terms of eccentricity. The conical section type is also dependent on the major semi-axis and energy. Table 2 shows the relationship between conical section type in relation to eccentricity, major semi-axis, and energy.

9.1 Circular trajectory

It is assumed that the position of the solid body is described by a vector $\vec{r}$ relative to the center of Earth $\boldsymbol{C}$, as shown in Figure 3, which illustrate the initial coordinate system of the solid body [10].

If the solid body receives an acceleration motion, then a force described by Newton's first law acts on it:

$$F = m\frac{d^2r}{dt^2} \tag{20}$$

However, the $\boldsymbol{F_c}$ centripetal force given by the relationship (4) also acts on the solid body. Therefore, from the equality of the two forces, it is obtain:

$$-m\frac{\mu r}{r^3} = m\frac{d^2r}{dt^2} \tag{21}$$

Which can also be written:

$$\frac{d^2r}{dt^2} + \frac{\mu r}{r^3} = 0 \tag{22}$$

This is a second-order linear differential equation which in practical applications, it is solved for the unknown variable $\boldsymbol{r}$ putting conditions at the limit.

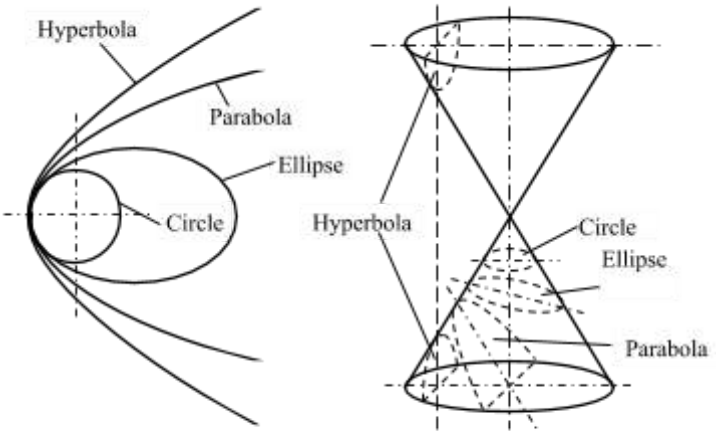

Figure 2

9.2 Elliptical trajectory

The assumption that the satellite follows a circular trajectory is sufficient to calculate the orbital period. However, in general, solid bodies do not move exclusively on circular orbits around a center of mass ***C***. As shown in Table 2 and Figure 2, the shape of the orbital trajectory of a solid body depends on the eccentricity value ***e*** [10].

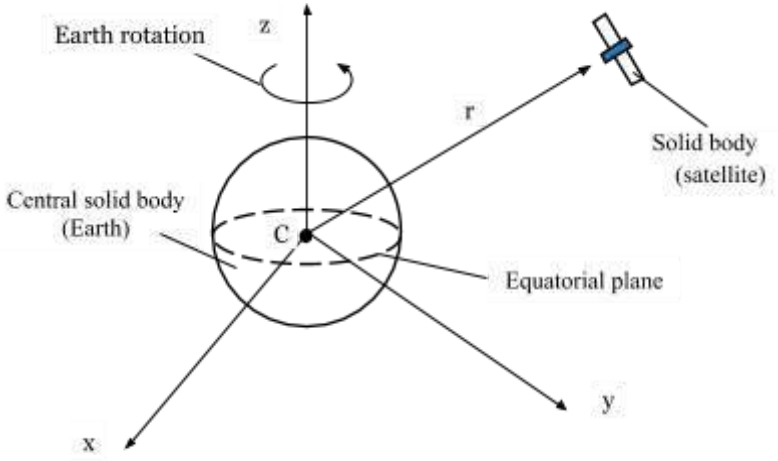

Figure 3

In the case of an elliptical trajectory, the unknown variable ***r*** and its unit vector $\vec{r}$ are time functions. These are in the report:

$$r = r(t)\vec{r}(t) \tag{23}$$

In order to solve the equation (22) the first and the second derivative, $\frac{dr}{dt}$ and $\frac{d^2r}{dt^2}$, must be determined using the product rule:

$$\frac{dr}{dt} = \frac{dr(t)}{dt}\vec{r}(t) + \frac{d\vec{r}(t)}{dt}r(t) \tag{24}$$

Equation (24) it is resolved by expressing ***r*** in a polar coordinate system with a simpler dependence on time and angles. In the polar coordinate system, the orbital plane of the solid body coincides with the xy plane. The coordinate system is shown in Figure 4.

Converting Cartesian coordinates into polar coordinates (by cylindrical form) can be done with the following relationships

$$r_0 = x_0\vec{x}_0 + y_0\vec{y}_0 = r_0\vec{r}_0 \quad (25)$$

$$\vec{r}_0 = cos\varphi_0\vec{x}_0 + sin\varphi_0\vec{y}_0 \quad (26)$$

$$\vec{\varphi}_0 = -sin\varphi_0\vec{x}_0 + cos\varphi_0\vec{y}_0 \quad (27)$$

With these values, equation (22) becomes:

$$\frac{d^2r_0}{dt^2} + \frac{\mu r_0}{r_0^3} = 0 \quad (28)$$

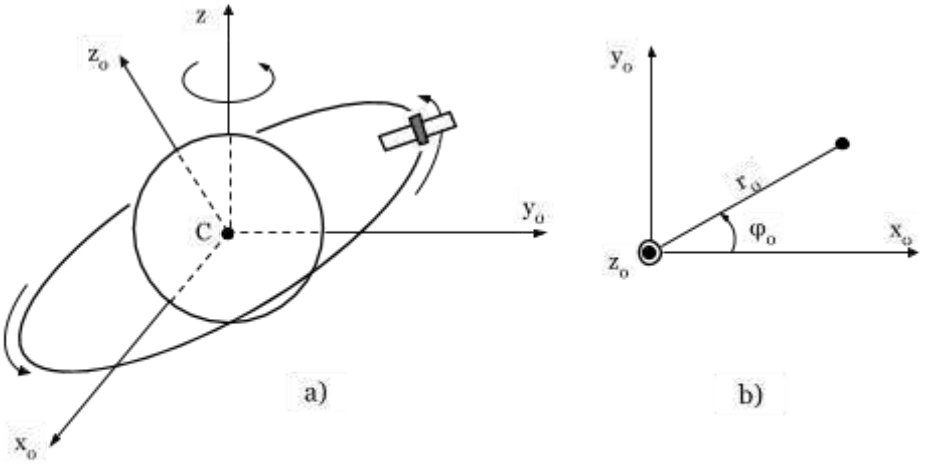

Figure 4
a) the polar coordinate system
b) $x_0 - y_0$ plane viewed from above

The solution of this equation has two components: a radial one $(\vec{r}_0)$ and another axial $(\vec{\varphi}_0)$. Deriving the left side of the equation (28), the radial component is given by:

$$\frac{d^2r_0}{dt^2} - r_0\left(\frac{d\varphi_0}{dt}\right)^2 = -\frac{\mu}{r_0^2} \quad (29)$$

and the axial component is:

$$2\frac{dr_0}{dt}\frac{d\varphi_0}{dt} + r_0\frac{d^2\varphi_0}{dt^2} = 0 \quad (30)$$

Dividing the equation (24) with $\boldsymbol{r_o}$ and applying the product rule for the left hand side of this equation followed by derivation with respect to the variables $\boldsymbol{r}$ and $\boldsymbol{\varphi_o}$, is obtains:

$$\frac{1}{r_0}\frac{d}{dt}\left(r^2\frac{d\varphi_0}{dt}\right) = \frac{1}{r_0}\left(2r\frac{d\varphi_0}{dt} + r_0^2\frac{d^2\varphi_0}{dt^2}\right) \quad (31)$$

Is observed that the right hand side of equation (31) is similar to equation (30). It follows from this that:

$$\frac{1}{r_0}\frac{d}{dt}\left(r^2\frac{d\varphi_0}{dt}\right) = 0 \quad (32)$$

which means that:

$$r^2\frac{d\varphi_0}{dt} = constant = h \quad (33)$$

where $\boldsymbol{h}$ is the angular momentum per the mass unit [m²/s] or [N m s].

On the other hand, solution of the equation (29) can be of the form:

$$r_0 = \frac{h^2}{\mu + Ah^2 cos(\varphi_0 + \theta_0)} \quad (34)$$

where $\boldsymbol{A}$ is an integration constant and $\boldsymbol{\theta_o}$ [rad] is the angle covered by the solid body during $\boldsymbol{t}$ [sec]. This equation can be written as:

$$r_0 = \frac{\frac{h^2}{\mu}}{1 + \frac{Ah^2}{\mu}cos(\varphi_0 + \theta_0)} = \frac{p}{1 + ecos(\varphi_0 + \theta_0)} \quad (35)$$

which represents *the equation of an ellipse in polar coordinates*. The values of $p = \frac{h^2}{\mu}$ also represent the *semilatus rectum* (right half) of the ellipse [m], and $e = \frac{Ah^2}{\mu}$ is *the eccentricity of the ellipse* [m]. It can eliminate $\boldsymbol{\theta_o}$ by aligning the $\boldsymbol{x_o}$ axis of the polar coordinate system and its coincidence with the major semi-axis of the ellipse, and is obtain:

$$r_0 = \frac{p}{1+e\cos\varphi_0} \quad (36)$$

The orbital path in the polar coordinate system is illustrated in Figure 5. The solid body moves on an elliptical trajectory relative to the origin of the coordinate system ***C***. The ellipse's outbreaks are located at points F_1 and F_2. In the example of Figure 5, the Earth is located at the focal point F_2. This is the first of three laws of Kepler's planetary movement: the orbit of a smaller solid body relative to a larger solid body is always an ellipse, with the center of mass of the larger solid body coinciding with one of the two focal points of the ellipse.

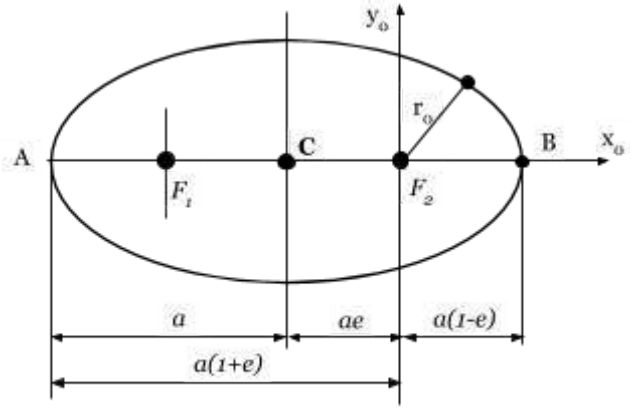

Figure 5

The length of the major semi-axis of the ellipse is:

$$a = \frac{p}{1-e^2} \quad (37)$$

while the length of the minor semi-axis is:

$$b = a\sqrt{1-e^2} \quad (38)$$

It is assumed that a solid body, such as the Earth, is located at the focal point F_2. Another solid body of smaller size, such as a satellite, crosses the orbital path and reaches in points **A** and **B**. These points are the farthest, or closest to Earth, respectively.

X. ORBITAL ELEMENTS

To describe mathematically an orbit, six parameters must be defined, named *orbital elements*. These are [2, 3 and 3]:

- Major semi-axis, a
- Eccentricity, e
- Inclination, i
- Argument of periapsis, ω
- Time of periapsis passage, T
- Longitude of ascending node, Ω

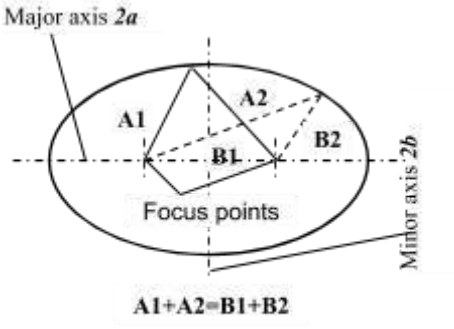

Figure 6

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An orbital satellite follows an elliptical trajectory, and the center of the planet, called the central solid body, is located at one of the two focal points. An ellipse is defined to be a closed curve having the following characteristic: for each point on the ellipse, the sum of its distances to the focus points is constant (see Figure 6).

The longest and shortest lines that can be drawn through the center of an ellipse are called the *major* (the main) *axis* and *minor* (secondary) *axis*, respectively.

The major semi-axis ***a,*** is half of the main axis and represents the mean distance of the satellite relative to one of the focus points.

Eccentricity ***e*** is the distance between the focal points divided by the length of the main axis and has a value between zero and one. An eccentricity equal to zero indicates a circle.

Inclination ***i***, is defined to be the angular distance between the satellite's orbital plane and the equator of its first plane (or elliptical plane in the case of heliocentric or sun-centered orbits). A zero-degree inclination indicates an orbit around the equator of the central solid body in the same direction as its rotation, a direction called *prograde* or directly. A 90 degree inclination indicates a *polar orbit*. An inclination of 180 degrees indicates a *retrograde equatorial orbit*. A retrograde orbit is one in which a satellite moves in a direction opposite to the rotation of its planet.

Periapsis is the point on an orbit closer to that of the central solid body. The opposite of periapsis, that is the most distant point on an orbit, is called *apoapsis*. Periapsis and apoapsis are usually modified to apply to the orbital body reported to the central planet, such as *perihelion* and *aphelion* for the Sun, *perigee* and *apogee* for Earth, *perijove* and *apojove* for Jupiter, *perilune* and *apolune* for the Moon etc.

The periapsis argument ***ω*** is the angular distance between the ascending node and the periapsis point (see Figure 7).

The time of periapsis passage ***T*** is the moment when a satellite moves through its point of periapsis.

Nodes represent the points in which an orbit crosses a plane, such as a satellite or another solid body that crosses the equatorial plane of the Earth. If the satellite or a solid body crosses the plane that goes from south to north, the node is called a node *ascending* (N_1); if it moves from north to south, it is a *descending node* (N_2).

Longitude of ascending node ***Ω*** is the celestial longitude of the node. The celestial longitude is analogous to the Earth's longitude and is measured in degrees counter-clockwise from zero, where the zero point is in the direction of the vernal equinox.

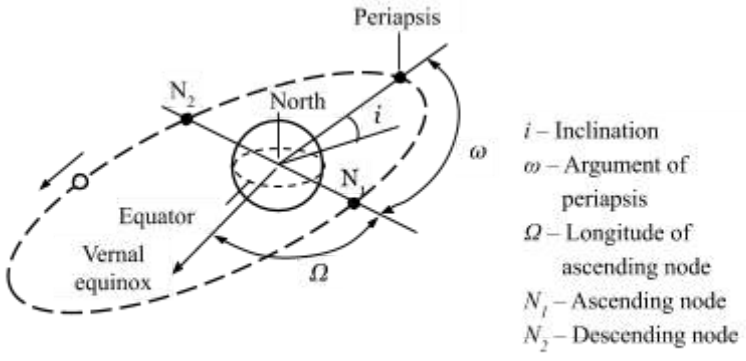

Figure 7

Generally, three observations of a solid body in orbit are needed to calculate the six orbital elements above. Two other parameters are often used to describe the orbits and are represented by true anomalies of the period. *Period P*, is the length of time required for a satellite to go through an orbit. *True anomaly* is the angular distance of a point (center of mass of a solid body) on an orbit that has passed through periapsis and is measured in degrees.

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ABSTRACT

Archaeological investigations found the ruins or remains of old irrigation systems, as old as 6th millennium BCE to 250 BCE, in various countries like Mesopotamia and Egypt, Peru, Indus valley in Pakistan. Even water storage systems were built at Girnar, Egypt ancient Persia developed by Qantas in Asia, Middle East and North Africa, Sri Lanka, China and Korea. In India during Vedas time, irrigation was done on small land patches, with anicut on Cauvery and upper river valleys in north India. Water is a prime natural resource and used for multiple uses viz. domestic, irrigation, industry, power generation, navigation etc.. Therefore, water should be used in integrated manner to maximize economic and social welfare. Integrated Water Resources Management's (IWRM) foundation as a global approach was laid at and after the 1992 conferences in Dublin (International Conference on Water and the Environment) and Rio de Janeiro (United Nations conference on Environment and Development, or the Earth Summit). The Global Water Partnership (GWP) was established in 1996 and became the main social carrier of the notion. The GWP promotes IWRM by creating forum at global, regional and national levels, designed to support stakeholders in the practical implementation of IWRM.

In this paper historical review of irrigation development in India and State of Maharashtra has been taken. Water policy and relevance of integrated water resource management is also studied. Maharashtra state is pioneer to implement Integrated State Water Plan (ISWP) in India. This study also reveals assessment of availability of water and equitable distribution of water in the Maharashtra state.

Keywords: water policy, integrate water plan, equitable water, transfer of water.

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I. INTRODUCTION

Water is a prime natural resource. Acknowledging the vital importance of water for human and animal life, for maintaining ecological balance and for economic and developmental activities of all kinds, considering its increasing scarcity, the planning and management of this resource and its optimum, economical, equitable and sustainable use has become a matter of the utmost urgency. Therefore, water should be used in judicial and integrated manner to maximize economic and social welfare. Integrated Water Resources Management's (IWRM) foundation as a global approach was laid at and after the 1992 conferences in Dublin (International Conference on Water and the Environment) and Rio de Janeiro (United Nations conference on Environment and Development, or the Earth Summit). The Global Water Partnership (GWP) was established in 1996 and became the main social carrier of the notion. The GWP promotes IWRM by creating forum at global, regional and national levels, designed to support stakeholders in the practical implementation of IWRM. The distribution of water resources is uneven over a

large part of the State. Such area is therefore, water deficit whereas a small part is bestowed with abundance in water. The water is used for multiple uses as domestic, irrigation, industry, power generation, navigation etc. Water which was once considered as abundant has now, become the scarce and economic resource. The availability of water resources is random, uneven and erratic over most of the part of the State. The State Water Policy formulated by the Government of Maharashtra in 2003 envisages that, the water resources of the State shall be planned, developed, managed with a river basin and sub basin as the unit. This policy states that, the distress in water availability during deficit period shall be shared equitably amongst different sector of water use and also amongst upstream and downstream users.

II. OBJECTIVE

The basic objective of this paper is to take historical review of irrigation development, water policy and implementation of integrated state water plan for judicial and equitable distribution of water in the State of Maharashtra, India.

III. METHODOLOGY

Only secondary data like books, research papers, Reports of high level Committees, Government. Commission's report and websites, Interstate water plan etc. are used for the present research paper.

IV. BACKGROUND

4.1 History of the irrigation development in the world

Archaeological investigations have identified the evidence of irrigation in Mesopotamia and Egypt, as early as the 6th millennium BCE, to support the crops in low rainfall area. In the Zana Valley of the Andes Mountains in Peru, archaeologists found remains of three irrigation canals from 4th millennium BCE to 9th century CE. The Indus valley Civilization in Pakistan and North India (from 2600 BCE) also had an early canal system, with extensive network of canals used for the purpose of irrigation. Even storage systems were developed including the reservoirs built at Girnar in 3000 BCE. There is evidence of ancient Egyptian pharaoh Amenemhet- III in twelfth dynasty (about 1800 BCE) having natural lake to store surplus water due to flooding of Nile, to use during dry season.

In Korea, the world's first water gauge was discovered in 1441 CE, by Jung Young Sil, Engineer, under the active direction of the King Se Jong. This nationwide system was used to measure and collect rainfall for agriculture application. With this instrument, planners and farmers could make better use of the information gathered in the survey.

Ghiyasuddin Tughluq (1220-50) is known to be the first ruler who encouraged digging canals. The Mughal Emperor Firoz Shaha Tughluq got executed one western Yamuna Canal near Delhi in the year 1350. After about 200 years, Emperor Akbar made some developments in the same canal and diverted some water to Hissar district in the year 1568. During the period of Shahajahan one branch canal was taken up to Delhi City through the old existing canal. He has also executed 180 Km long canal from river Ravi to Shalimar garden Lahore. During the year 1730 Emp. Ahmad Shaha got executed the Yamuna right bank canal, which was modified by the British Ruler to irrigate the land of 1.5 Lac Ha in 19th century.

4.2 Irrigation Development In British Era

The concluding years of the nineteenth century saw a horrible famine. This has forced the British Government to undertake at least protective irrigation schemes, though out of reluctance. The work of Ganga canal was also started in the year 1834 and completed in 1854. Cauvery and Godavari canals were also taken up in 1845 the work of Khodshi weir on Krishna River was started in 1870 with canals. The Khadakwalasa dam on Mutha river was completed in 1875. The work of Vihar (1860) Povai and Tulshi (1876) and

Tansa (1883) completed for drinking and industrial water in Mumbai. The dams at Ghodzari, Aswalamendha and Naleshwar in Vidarbha.

4.3 Irrigation Development during Post-Independence Period

India attained Independence in the year 1947 and the Maharashtra State as of today, came into being in 1960. At the time of Independence net irrigated area of India under British Rule which included Pakistan and Bangladesh was 28.2 Million ha, (24.1 %) out of total cultivable area of 116.82 Million ha. After partition, net irrigated area in India and Pakistan was 19.42 Million ha (19.7 %) and 8.82 Million ha (48.1 %), out of the cultivable area of 98.52 Million ha and 18.32 Million ha, respectively. The Plan period, in India commenced from 1951.

Lot of major dams were completed in all parts of the State on rivers like Girna, Mula, Mutha, Deena, Bor, Manar, Koyana, Veer, Purna etc. The irrigation of 3.86 LHa was created in the State of Maharashtra at the time of formation of State on 01.05.1960.

V. STATE WATER POLICY

Water being a State subject, State of Maharashtra had framed its water policy in the year 2003, which was subsequently revised in May, 2011. Since adoption of this policy, significant positive changes have occurred in the water scenario of the State. However, some of the issues and challenges faced by the State water sector still continue and require policy reforms.

Government of India (GOI), also revised its first i. e. of 1987 National Water Policy, and released, the National Water Policy in the year 2012. GOI as per the provision of clause 16.2 of their policy desired, to revise State Water Policy in aligned with the objectives of their policy. Accordingly, the State of Maharashtra has revised the water policy on dated 05.09.2019 with the following objectives.

1. To ensure clean water and sanitation in the State.
2. Judicious and strategic sectoral allocation of water among different water use sectors.
3. Equitable distribution of water and assured access to allocated quota of water.
4. Protection of ecosystems.
5. To protect and enhance water quality of surface as well as ground water.
6. Increasing productivity and efficiency of water use.
7. To make systematic transition from the water resources development mode to an integrated water resources mode with appropriate reforms.

5.1 The State has also achieved following reforms and goals in water Governance.

1. The irrigation potential has been increased from 3.86 LHa (before, 1960-formation of State) to 53.04 LHa on State Sector Projects and 18.01 LHa on Local Sectors schemes totaling to 71.05 LHa till June, 2019. However, the actual utilization of potential is 39.50 LHa on State projects in 2017-2018.
2. Bench marking of water resources projects has been introduced by the WRD (Water Resources Department)as it is very powerful management tool helps in, analyzing and improving performance of water resources projects.
3. Water auditing is the scientific approach to analyze water accounts of the projects. The system performance and water use efficiency can be improved by reducing the losses on overall system.
4. Effectively and successfully managed drinking water supply to most of the cities and towns along with augmented supplies to rural areas.
5. Industrial growth has been accelerated along with the increasing hydro-power capacity from 290 MW to 3684 MW up to March, 2019.
6. The Water User Associations (WUAs) of 5326 numbers have been formed on the project command area introducing Maharashtra

Management of Irrigation Systems by Farmers (MMISF) Act, 2005.

7. The Maharashtra ground water (Development and Management) Act, 2009 has been enacted, to regulate ground water resources of the State through MWRRA.
8. The Maharashtra Water Resources Regulatory Authority (MWRRA) has been established to regulate, facilitate, and ensure judicious, equitable and sustainable management, allocation and utilization of water resources within the State of Maharashtra.

Maharashtra is the first State in the country to introduce such type of Act with quasi-judicial powers for imposing punishment under clause 26 of the MWRRA Act.2005.

5.2 Integrated State Water Plan

As stated in clause 11(f) of powers, functions, and duties of, MWRR Authority, the clearance to irrigation projects can be given, when it is in conformity with Integrated State Water Plan approved by the Govt. committees prescribed under cl.15 &16 of the Act-2005. The clause 15 and 16 of the MWRRA Act, 2005, provides to constitute the State Water Body with Chief Secretary of the State as President, along with 10 other Secretaries of water related departments, as the member of the Board. The Board has to prepare and recommend the draft of Integrated State Water Plan (ISWP) on the basis of basins and sub basin-wise water available and proposed use within State. The clause 16 of MWRRA Act, 2005 also provides to constitute the State Water Council, with the Chief Minister of the State as President, along with 15 other Ministers of Line Departments, as the members of the Council. This Council has to approve the draft ISWP submitted by the State Water Board duly modified, if required within a period of 6 months, with due cognizance of the directives given by the Governor of the State, for the removal of regional imbalance. The plan so approved by the council, shall become the ISWP to be implemented in the State for 5 years, i.e. till next review.

Accordingly, the State Water Council has approved the ISWP for 6 basins in the State of Maharashtra, vide letter dated 07.03.2019. The ISWP covers the status of both surface and ground water of each basin with available surplus water, to be used for deficit basin. The important concept of having minimum 3000 cum of water per hectare of cultivable land for all the sub basins in the State is decided by the SWC while finalizing the ISWP. The water from surplus or abundant sub basins (more than 8000 cubic meter per hectare) is therefore, to be calculated and proposed to be transferred to deficit or highly deficit basins, to make the total available water up to 3000 cubic meter per hectare. As such all the sub-basins of the State, will be brought to the category of Normal water basin, having minimum criteria of 3000 Cum of water per hectare of cultivable land. This is the most important and appropriate decision taken by the SWC for equitable distribution of water in the State.

The State of Maharashtra has erratic, random and uneven distributed rainfall in every basin. The water of 55% is available in West Flowing Rivers Basin over an cultivable area of 6.4% and remaining 45% of water is available on 93.6% area in the State. The ISWP is therefore, very important document to decide the proper and equitable use of available water resources so that, no basin or sub basin will be left in deficit category, because of getting required water from surplus basin in the State of Maharashtra.

5.3 Details of the State of Maharashtra (India)

Maharashtra is the second highest populated, third largest in area and the second most industrialized state in India. The state of Maharashtra came into existence on 1st May 1960.The Geographical location of the Maharashtra is bounded between latitude 16.4 to 22.1 N and longitude 72.6 to 80.9 E. As per 2011 census, the total population of Maharashtra is 112.37 Million, which is 9.29% of the India's population (1210.19 Million). The State has the geographical area of 0.307 Million Sq. Km., which

is about 9.4 per cent of the total area of India. Maharashtra is highly urbanized State, with 45.2% population residing in urban area. The State has about 720 km long coastline along Arabian Sea.The Sahyadri mountain ranges extend almost parallel to western coast line, renowned as western Ghat. The average height of Sahyadri in Maharashtra is 900 m-1000m with higher altitude in the north and diminishes towards south. The State of Maharashtra is getting rain both from the South-West, & North-East monsoon. The average rainfall of the State is approximately 1360mm. The maximum rainfall, about 88 per cent occurs in four months between June to September, about 8 per cent between October to December and remaining 4 per cent after December. Further, rainfall is ranging from 400mm to 6000mm in different parts of the State. It is revealed from this, that there is significant variation in rainfall distribution and its occurrence. The State witnesses frequent drought conditions. Almost 42.5% area of the State is drought prone.

5.3 Basin wise Area Covered by ISWP

The Maharashtra is mainly covered by the basins of rivers Godavari, Krishna, Tapi, Narmada, Mahanadi, and with the Konkan strip of West Flowing Rivers. Thus there are total six basins in the State. The largest basin in the State is Godavari, where as the smallest basin is Mahanadi having less catchment area. The basin wise catchment area in Maharashtra is given in the Table No 1 and Map in Figure No. 1.

Table No.1: The basin wise catchment area in Maharashtra

Sr. No.	River Basin	Total Catchment Area (Sq.km)	Catchment Area in Maharashtra (Sq. km)	% of C.A. in Maharashtra (Col.4/3)	% Of each basin in Maharashtra (Col.4/4)
(1)	(2)	(3)	(4)	(5)	(6)
1	Godavari	3,12,811	1,52,598	48.78%	49.7%
2	Krishna	2,58,948	69,425	26.81%	22.6%
3	Tapi	65,145	52,058	79.06%	17.0%
4	WFR(Kokan)	31,780	31,780	100%	10.3%
5	Narmada	98,976	1,048	1.0%	0.3%
6	Mahanadi	1,41,672	354	0.23%	0.1%
7	Total	9,09,332	3,07,263	33.79%	100%

Source : ISWP Vol. I Page No. 148

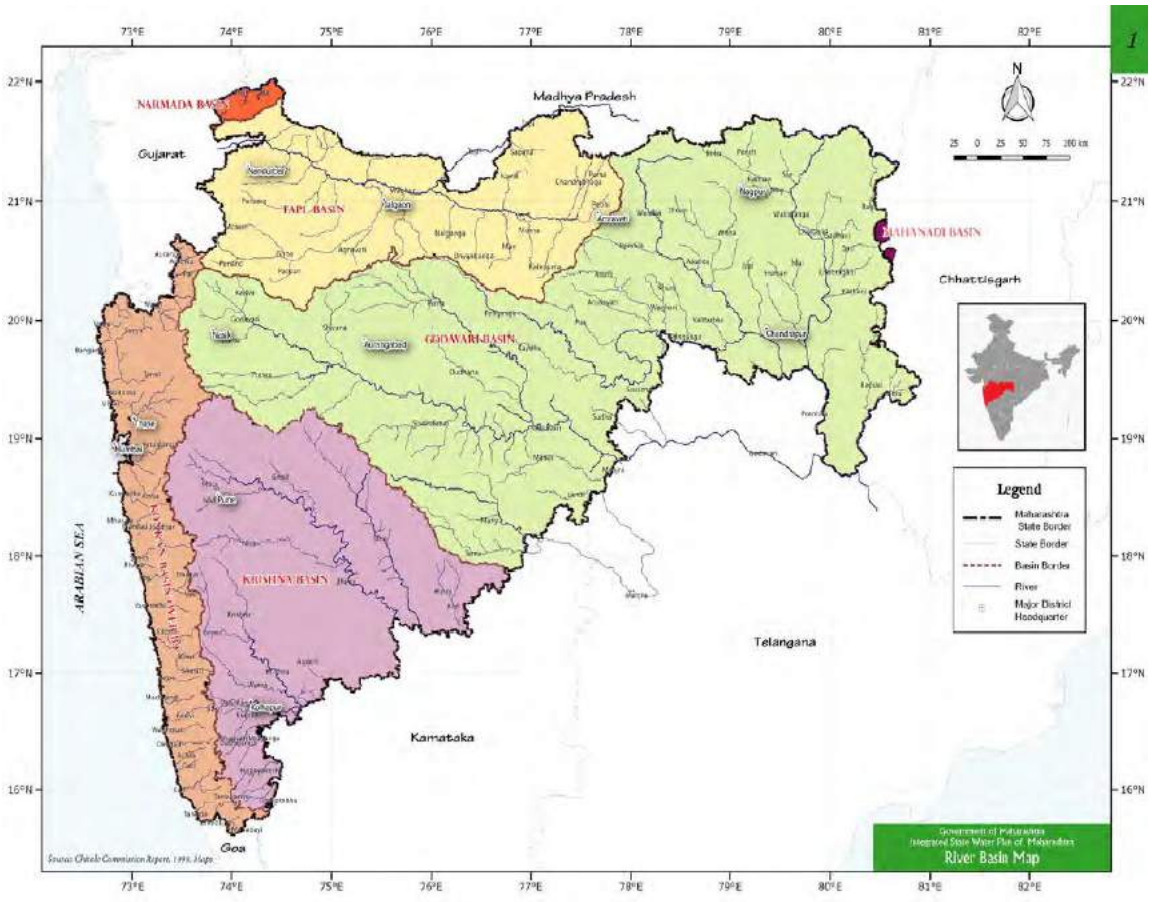

Figure No. 1: Map showing river basins in Maharashtra

According to the Maharashtra Water & Irrigation Commission Report (1999), the ultimate irrigation potential of Maharashtra State has been estimated as, 12.6 Mha of which 8.5 Mha is from surface water and 4.1 Mha from ground water sources. However by the end of June 2019, irrigation potential created is 5.304Mha on State Sector projects and 1.845 M ha (2018) on Local Sector projects. Thus, the total irrigation potential created in Maharashtra; on State and Local Sector schemes is 7.149 Mha. till the end of June 2019.

5.3 Water Resources of the Maharashtra State

The surface water availability in the State of Maharashtra, at Average annual dependability is 202.6 BCM, which consists of 170.3 BCM of surface water and 32.3 BCM of groundwater.. The surface water available at 75% dependable yield is 162.2 BCM, which consists of surface water of 139.6 BCM and the groundwater at 70% net recharge, as per recommendations of State Water Board (SWB) is, 22.6 BCM. The storage capacity created through State Sector water resources projects is 42.85 BCM as on June, 2017

Except the West Flowing Rivers of Konkan, Maharashtra shares water for remaining 5 river basins with the neighbouring State. Various inter-state river water disputes, Tribunal awards / Agreements and decisions on water sharing have limited the use of surface water resources of the State to about 116.2 BCM, of which 64.2 BCM (55%) contribution is alone of West Flowing Rivers basin of Konkan area. However, the cultivable area of this region / basin is very limited (6.4%), comprising of narrow strip of 50 Km between Sahyadri ranges and Arabian sea. Hence, there is a limitation on local use of entire available water. The cultivable area of 5 basins (93.6%) is having only 45% of water resources. Due to this constraints, about 39.8% area of the State lies in deficit or highly deficit category. The

State is experiencing water shortage and recurrent droughts.

5.4 Ground Water

Another prime resource of fresh water is in the sub-surface of the earth, which is infiltrated due to rainfall occurring in that area, is known as ground water. Which is main source of drinking and agriculture use in rural area of Maharashtra. Occurrence and distribution of ground water beneath the earth, varies widely depending on geology, geohydrology, geography and rainfall in that area. Deccan basalt of Maharashtra is one such region of India, which faces acute shortage of ground water due to continues increase demand of groundwater, but as compare to demand, recharge of rainwater is very less, which results lowering of water table every year.

The basin wise surface water and ground water available in the state is shown below, in Table No. 2

Table No. 2: Basin Wise Surface and Ground Water Available in Maharashtra

(Figures in Mcum)

Sr. No.	Basin	Surface water			Ground water		Total water Allowed (SW+GW)
		Av. Avail.	75% Dependable	Allowed by Tribunal	Net Recharge	70% Net recharge	
1.	2.	3.	4.	5.	6.	7.	8. (5+7)
1.	Godavari	51757	38607	29023	17498	12248	41271
2.	Krishna	33710	29299	16562	7817	5479	22041
3.	Tapi	9656	7027	5995	4651	3256	9251
4.	WFR	74739	64218	64218	2264	1583	65801
5.	Narmada	309	308	308	35	25	333
6.	Mahanadi	165	103	103	27	19	122
	Total	170336	139562	116209	32292	22610	138819

5.5 Surface and Ground Water Availability

The water availability, basin wise, as well as, total in the State, has been computed based on natural water availability and restrictions due to various Tribunals, committee Reports, mutual Agreements between the States etc. The information, of basin wise catchment area, metrological set up, overall meteorology of the State, is considered for computation of water availability. The water availability worked out per hectare is deciding strategy for further scope of water resource development in different basins and sub basins. The information regarding allowed surface water in Cubic meter per hectare, and even surface and ground water together, in Cum. per hectare, is shown below in Table No. 3, to decide the category of the basin.

Table No. 3: Basin Wise Water Allotted Per Hectare in Maharashtra

Sr. No.	Basin	Cultivable Area (Lha)	Surface water allocated (Mcum)	Water Available (Cum/Ha)	Total water Sur+GW (Mcum)	Water Available (Cum/Ha)
(1)	(2)	(3)	(4)	(5) (4/3)	(6)	(7)(6/3)
1	Godavari	108.41	29023	2677	41271	3807
2	Krishna	55.98	16562	2959	22041	3937
3	Tapi	34.44	5995	1741	9251	2686
4	WFR	13.63	64218	47115	65801	48277
5	Narmada	0.65	308	4738	333	5123
6	Mahanadi	0.03	103	31647	122	41000
	Total	213.14	116209	5452	138819	6513

Source: ISWP 2019 Page No. 160 and 265

The total surface water available at 75% dependability is 139562 and ground water at 70% net recharge available is, 22610 Mcum. Thus, the total water available for use is 162172 Mcum. Out of this, the total basin-wise surface water allocated and ground water available in the Maharashtra State as shown in above table, is (116209 + 22610) 138819 Mcum.

As stated in the report of Maharashtra Water and Irrigation Commission (1999), the category of basin is decided from the criteria of available water in Cubic meter per hectare of cultivable area is given below, i.e.

i. Highly deficit - 0 to 1500 Cum/ Ha

ii. Deficit- 1500 to 3000 Cum/ Ha

iii. Normal – 3000 to 8000 Cum/ Ha

iv. Surplus water – 8000 to 12000 Cum/ Ha

v. Abundant - above 12000 Cum/ Ha

The above stated criteria, if considered only for Surface Water, then the Godavari, Krishna, and Tapi basins are in the category of Deficit Basins, (col no. 5 in above table) being less water than 3000 Cum. Per hectare.

5.6 Water Resources Development

Water is one of the principal resources essential for human existence and it is required for various purposes such as drinking and domestic water needs, agriculture, industry, hydro and thermal power generation, survival of environment and many others. Availability of water in Godavari/ Krishna/Tapi/Narmada/ West Flowing Rivers (konkan). Mahanadi basins in Maharashtra, for the most part, is from the monsoon rainfall available from June to October which is unevenly distributed over both space and time, whereas water demand for above purposes, except for the agriculture to a certain extent, is mostly evenly distributed over both space and time. The scenario dictates need of development of water resources.

5.6 The Status of Irrigation in the State of Maharashtra.

The basin wise status of the planning, for the irrigation projects completed or to be completed, in the State is considered in the Integrated State Water Plan. The details of the State Sector irrigation projects and Local Sector schemes completed, in progress with the overall position of storage created and its use for the command area of the projects, the overall position of the percentage of irrigation created per hectare of

irrigation and water planned to use per hectare, is analyzed and shown below.

The status of three basins i.e. Godavari, Krishna and Tapi is considered individually but, the remaining small three basins i.e. Narmada, Mahanadi and West Flowing Rivers, area being only 6.7% are considered together and shown in the Table No 4. It is seen from this table that, the water use of 47599 Mcum is done so far, out of the total water of 1,16,209 Mcum allotted to be used for the State. This shows that, only 41% of water is being used in the state after constructing 8297 numbers of projects and proposing the irrigation potential of 74.53 LHa. The average irrigation potential may reach up to 35%, (sr.no 11) in the State. The Krishna basin will reach to 43.1% of irrigation potential as against the other basins will be lying behind the Krishna basin in the state.

Table No.4: Present Irrigation Status of Basins in Maharashtra

Sr. No.	Particulars	Unit	Godavari	Krishna	Tapi	Nar+Maha+ WFR basins	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Sub basins	Nos.	30	5	5	30	70
2	Cultivable Area	LHa	108.42	55.98	34.44	14.29	213.13
3.	Percentage of Cult. Area	%	50.8	26.3	16.2	6.7	100
4.	Surface water allocated	Mcum	29023	16562	5995	64629	116209
5.	Water Allocated per Ha CA(4/2)	Cum	2677	2959	1741	45226	5453
6.	Category of basin	-	Deficit	Deficit	Deficit	Abundant	Normal
7.	Irri. Projects	Nos.	4774	1069	1671	783	8297
8.	Irrigation potential	LHa	37.	24.15	10.07	3.31	74.53
9.	Water use prop.	Mcum	23397	14837	6295	3070	47599
10.	Irrigation per MM^3 (8/9)	Ha	158	162.8	160	170.8	156.60
11.	Percentage of irrigation (8/2)	%	34.1	43.1	29.2	23.2	35
12.	Proposed Target	%	45	45	45	45	45
13.	Difference to achieve (12-11)	%	10.9	01.9	15.8	21.8	10
14.	Addl. water required(13x2/10))	Mcum	7480	653	3401	1824	13358

5.7 Total Surface Water Requirement

Assessment of water balance in each of the basin in the state is most important aspect which will govern water resources management and development in the State. The status of water balance, in each of the basin and the present scenario will help in management of water resources in a better way and will help in deciding the strategy for future development. For arriving water balance in each of the basin and its sub-basin, availability of surface as well as ground water as arrived with restrictions due to the various tribunal awards, reports of the Committees and interstate agreements, have been considered. In addition to natural surface water available, availability due to inter basin and intra-basin water transfer, water from domestic and industrial use has also been considered.

The basin wise total surface water requirement as being computed considering water allotted and its use as explained above. The details of the basin wise water balance are given in the Table No 5 below.

Table No. 5: Basin wise surface water requirement
(Figure in Mcum)

Sr. No.	Basin	Total water requirement for-				Total Use of SW.
		Irri. use	Domestic Use	Industrial Use	Export to othr.basin	
1	2	3	4	5	6	7
1	Godavari	23397	1273	869	242	25781
2	Krishna	14837	318	06	3139	18300
3	Tapi	6295	205	41	00	6541
4	WFR	3065	2262	7802	550	6657
5	Narmada	01	00	00	300	301
6	Mahanadi	04	01	00	00	05
	Total	47599	4059	1696	4231	57585

Total surface water allocated to the State at present is 1,16,209 Mcum, which includes water availability from allocated water, regeneration water, import by way of inter basin transfer. Total planned water use at present is (47599+ 4059+1696+4231), 57585 Mcum. which include use for domestic, industrial, irrigation, ecological purpose and export by way of inter-basin water transfer like hydro water etc. At present(116209-57585) 58,624 Mcum, of water is in balance. Most of the water balance, is in WFR Basin.

But, looking to the equitable water distribution, it is necessary to bring all the basins of the State up to 45% of irrigation potential. The additional water shown at Serial No. 14 of the above table No.4, will have to be transferred from area of surplus basin to deficit basins. Though ample water is available in WFR basin, it is lying at 150-200 Mtrs. elevation. And transfer of water to other basins like Godavari, Krishna and Tapi, the water is to be lifted for about 200 to 400 m. height. Thus it is the costly water. So the quantity of water required for bringing equitable

distribution of irrigation potential up to 45% for all basins in the State, is only to be lifted. The details of basin wise quantity of balance water, are shown below in the Table No. 6.

Table No. 6: Basin wise surface water balance
(Figure in Mcum)

Sr. No.	Basin	Water allotted	Present Water Use	Addl. Use for Equitable Distribution	Total water use (4 + 5)	Balance Water (3-6)
1	2	3	4.	5	6	7
1	Godavari	29023	25781	7480	33261	(-)4238
2	Krishna	16562	18300	653	18953	(-)2391
3	Tapi	5995	6541	3401	9942	(-)3947
4	WFR	64218	6657	1719	8376	55842
5	Narmada	308	301	07	308	-
6	Mahanadi	103	05	98	103	-
	Total	116209	57585	13358	70943	45266

From the above table, the water to be transferred from surplus basin of WFR (Konkan) to the deficit basins for bringing the equitable percentage of irrigation potential, i.e. additional basin wise water required in the State is shown below.

1. Godavari Basin 4238 Mcum (150 TMC)
2. Krishna Basin 2391 Mcum (84 TMC)
3. Tapi Basin 3947 Mcum (140 TMC)

Total water Required 10576 Mcum (374 TMC)

5 .8 Ground Water availability

Ground water is one of the most important natural resources on the Earth. It plays important role in maintenance of economy, environment and standard of living of any society in the State. In the absence of immediate availability of surface water sources, the Rural population of about 75% is dependent upon ground water. It is equally important in river basin management. It has been the primary source of water supply for domestic, agricultural and industrial purposes. It is the single largest and most readily available source of irrigation, and large part of irrigation is depending on the ground water. Nearly 92% area of the State is occupied by the hard rock including basalt(82%) and metamorphic rocks(10%). These rocks have poor ground water yielding (specific yield ranges for 1-3%) capacity. As per the report on Dynamic Ground Water Resources as on 2013-14, out of the total 1531 watersheds of the state, 74 are categorized as over exploited (OE), 04 Critical(CR), 111 Semi Critical(SC), 04 Poor Groundwater Quality and rest 1338 are safe. Groundwater being a common pool resource needs to be managed through participatory approach. Basin wise ground water use is given below, in Table No. 7.

Table No. 7: Basin wise Ground Water Use
(Figure in Mcum)

Sr. No.	Basin	Total water use				Total Use of GW.	Balance
		Total water	Irri. Use	Domestic Use	Industrial Use		
1	2	3	4	5	6	7	8
1	Godavari	12248	7960	464	35	8459	3789
2	Krishna	5479	5142	248	-	5385	94
3	Tapi	3256	2769	187	-	2956	300
4	WFR	1583	241	81	-	322	1261
5	Narmada	25	-	09	-	09	16
6	Mahanadi	19	-	01	01	02	17
	Total	22610	16112	985	36	17133	5477

The overall position of surface and ground water available in the State and its use is shown above. The over all balance position of the surface and ground water is given in the Table No. 8 shown below.

Table No. 8: Abstract for total water balances in the State
Fig in MCum (TMC)

Sr. No.	Particulars	Total allotted / Available Water	Total water use	Balance Water
1.	2.	3.	4.	5.
1.	Surface Water	116209 (4104.9)	70943 (2505.9)	45266 (1599.0)
2.	Ground Water	22610 (798.6)	17133 (605.1)	5477 (193.5)
3.	Total Water	1,38,819 (4903.5)	88,076 (3111.0)	50743 (1792.5)

VI. CONCLUSIONS

While studying the water resources development and management in the State the quantity of basin-wise water available is calculated by considering 75 % dependable yield, the sub-basin wise catchment area and the respective run-off. As the rivers are flowing Inter-States (except WFR) the water allotted by the Tribunals is considered for utilizing in the respective basins of the State. This surface water is proposed to be used for developing irrigation potential and for Non Irrigation use like domestic and industrial purposes. As per the guidelines for sectoral water use suggested by the Maharashtra Water Resources Regulatory Authority (MWRRA) about 25 % storage of dams is proposed for N.I. use and rest of storage is used for developing irrigation potential in the command area of the project.

Looking to the status of developing the irrigation potential (table No.4), in the State of Maharashtra as shown at serial No. 12, all the basins are proposed to reach up to 45% of irrigation potential. Therefore, the additional water of 13358 Mcum is required with net of 10576 Mcum (374

TMC) for increasing the Irrigation Potential, is proposed by transfer of water from WFR basin.

For considering the overall position of water as shown in table No. 8, the total surface water use is 70,943 Mcum (2505.9 TMC) as against the total allocated water of 1,16,209 (140.9 TMC) and the surplus water of 45266 Million cubic meter (1599.0 TMC) is not economical to use, because of heavy lift involved in transfer of water from WFR basin. Similarly, the balance ground water of 5477 Mcum (193.5 TMC) can be used in respective basins. There is no restrictions on the use of ground water within the State boundary. It is therefore, in the interest of the State to extract all the ground water available within the State boundary (as permitted by the State Ground Water Development Act) and use the same for irrigation, domestic purpose, industries etc.

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ABSTRACT

Space environment causes unique alterations in astronauts' physiology that require the attention of clinicians and scientists. In this review an overview of the proffered solutions was provided to the effects of space environment on astronaut's physiology with special consideration to microgravity and space radiation. Living in microgravity environment impacts significant effects on the body systems such as the: cardiovascular system slows down; immune system changes; musculoskeletal system deteriorates and the sensory motor dysregulate. These systems effects cause disorders in the body of the astronauts' such as decreased bone formation and bone mass, decreased number of T lymphocytes, shift in body fluids, loss of balance and reduced heart rate. Space radiation also affects the circulatory, cardiovascular, musculoskeletal, immunological and gastro intestinal systems causing disorders such as increase of blood in the upper body, decreased heart rate, bone demineralization, muscle atrophy, immune dysregulation, change in appetite and nausea. Some solutions to the effects of microgravity and space radiation include exercise, use of dietary supplement with calcium and vitamin D and K, Health Stabilization Program (HSP), use of buckles and system straps, use of Lower Body Negative Pressure (LBNP), simulation of Earth gravity in spacecraft and use of anti-nauseate. In conclusion, building on the awareness about the dangers of the space environment on astronauts (especially those for long-term manned missions) and seeking to better understand the physiological challenges and proffering reviewed solutions to them are documented in this article.

Keywords: space environment, microgravity, radiation, astronaut, physiology.

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Possible Solutions to the Effects of Space Environment on Astronauts' Physiology

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ABSTRACT

Space environment causes unique alterations in astronauts' physiology that require the attention of clinicians and scientists. In this review an overview of the proffered solutions was provided to the effects of space environment on astronaut's physiology with special consideration to microgravity and space radiation. Living in microgravity environment impacts significant effects on the body systems such as the: cardiovascular system slows down; immune system changes; musculoskeletal system deteriorates and the sensory motor dysregulate. These systems effects cause disorders in the body of the astronauts' such as decreased bone formation and bone mass, decreased number of T lymphocytes, shift in body fluids, loss of balance and reduced heart rate. Space radiation also affects the circulatory, cardiovascular, musculoskeletal, immunological and gastro intestinal systems causing disorders such as increase of blood in the upper body, decreased heart rate, bone demineralization, muscle atrophy, immune dysregulation, change in appetite and nausea. Some solutions to the effects of microgravity and space radiation include exercise, use of dietary supplement with calcium and vitamin D and K, Health Stabilization Program (HSP), use of buckles and system straps, use of Lower Body Negative Pressure (LBNP), simulation of Earth gravity in spacecraft and use of anti-nauseate. In conclusion, building on the awareness about the dangers of the space environment on astronauts (especially those for long-term manned missions) and seeking to better understand the physiological challenges and proffering reviewed solutions to them are documented in this article.

Keywords: space environment, microgravity, radiation, astronaut, physiology.

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I. INTRODUCTION

Space environment is an astronautical branch: aerospace engineering and planetary physics that seeks to recognize and resolve the space-existing conditions. It is one of the most extreme environments imaginable (Ohnishi and Ohnishi, 2004). Spacecraft are exposed to extremes of temperature above the Earth's insulating atmosphere, both hot and cold, and a greatly increased danger of radiation exposure (Thirsk *et al.*, 2009a). The technological issues associated with leaving Earth and designing space propulsion systems have been studied for over a century, and they have been spent millions of hours of work on. This problem needs feedback from the physical and biological sciences, and is now the biggest obstacle facing human space exploration (other than funding). The risks or hazards of space shuttle are grouped into five categories related to their effects on the body of the astronaut. They are microgravity, isolation/confinement, hostile/closed environments, space radiation, and distance from Earth (Richard, 2014). The aim of this research is to proffer reviewed solutions to the effects of space environment on astronaut's physiology with

special consideration to microgravity and space radiation.

1.1 Microgravity

Microgravity is the very little amount of gravitational force experienced by an object in free fall due to some non-gravitational forces acting on them (Karthikeyan, 2019). It is also referred to as weightlessness due to minute gravity. Living in this kind of environment impacts the body in three important ways: loss of proprioception, fluid flow changes and musculoskeletal system deterioration (Elizabeth, 2017; Jaiyeola, 2019a). Long-term weightlessness has significant adverse effects, including muscle atrophy and skeleton degradation (osteopenia spaceflight) (Kanas and Manzey, 2008; Oluwafemi, 2018). Other significant effects include slowing down cardiovascular system functions, reduced red blood cell development, balance disorders, eye disorders and immune system changes (Neergard and Borenstein, 2019). Additional symptoms include fluid transfer (causing the astronauts "moon-face" appearance) (Toyohiro, 1993), body mass loss, nasal congestion, sleep disturbance, and constant flatulence. Research such as osteoporosis treatments, and the optimal timing for such therapies could be employed to mitigate the risk for astronauts developing premature osteoporosis. Adaptability training programs and the ability to perceive specific sensory information are being studied to alleviate problems related to balance performance that is being conducted to ensure that astronauts stay healthy before, during and after their mission.

1.2 Space Radiation

One of the first hazards of human mission to Mars is radiation and also the most difficult to visualize because space radiation is invisible to the human eye. Not only is radiation stealthy, it is often considered one of the most dangerous threats. Radiation exposure above Earth's natural defence raises the risk of cancer, affects the central nervous system, can alter cognitive function, decrease motor function and cause behavioural changes (Shiga, 2009). The space station is located just within Earth's protective magnetic field, and while astronauts are subjected to ten times higher radiation than on Earth, it is still a smaller dose than what deep space will impact. To mitigate this hazard, deep space vehicles should have significant protective shielding, dissymmetry, and alerts. In the field of medical countermeasures such as pharmaceuticals, work is also being done to help protect against radiation (NASA, 2017).

The National Aeronautics and Space Administrati on (NASA) identified four main physiologichazard s during exploration missions that could cause ser ious health problems for astronaut-crewsexposed to the interplanetary radiation environment.

These four space radiation risks are carcinogenesis, degenerative tissue effects, Central Nervous System decrements and acute radiation syndrome (Cucinotta *et al*., 2013).

II. EFFECTS AND SOLUTIONS OF MICROGRAVITY AND SPACE RADIATION ON ASTRONAUTS

Only minute amount of gravity has effect on astronauts within the microgravity environment o f space. Several of the effects of microgravity are observed within minutes to hours of exposure, while others require weeks or months to manifest. Skeletal impact loads typically associated with running and walking on Earth is greatly reduced or absent, because skeletal remodelling is dependent on the level of strain within the bone, this absence of loading is significant (Buckey, 2006b; Shackelford, 2008 and Cann, 1997). Table 1 shows the disorders and solutions of the effects of microgravity on astronauts.

Table 1: Disorders and Solutions to the effects of Microgravity on Astronauts

System Affected	Disorder	Solution
Musculoskeletal	• Decreased bone formation • Increased bone resorption • Decreased bone mass (lead to early onset osteoporosis) (Smith *et al*., 2005)	Resistance exercise; dietary supplement with calcium and amino acids; required daily exercise to keep muscles and bones from deteriorating.
Immunological	• Decreased number of T lymphocytes • Decreased response of T lymphocytes to potent activator • Alterations in cytokine/chemokine activity (Sonnenfeld *et al*., 1998)	Health Stabilization Program (HSP) to minimize or eliminate the possibility of occurrence of infectious disease among crew members
Cardiovascular	• Reduced heart rate, as the heart becomes less efficient other physiological functions of the body are affected • Reduced diastolic pressure • Post-flight postural hypotension and hypovolemia • Shift in body fluids	The use of systems of straps and buckles to help maintain an upright position should not be underestimated
Sensory-motor	• Loss of balance • Altered perception of orientation • Deconditioning of posture and gait control • Deconditioning of motion sensors • Deconditioning of the somatosensory system These could lead to blood redistribution toward the head causing altered responses of baroreceptor, nervous and endocrine systems (Katkov and Chestukhin, 1980)	Use of antihistamine promethazine which will help to prevent treat to nausea and vomiting, motion sickness and allergies.
Wound healing	• Impaired matrix formation	

	• Impaired proliferation and migration of cells into wound • Reduced wound collagen content • Impaired revascularization • Impaired keratinocyte migration	

Space radiation has recently been linked to a higher incidence of cataracts in astronauts. Outside of low Earth orbit safety, galactic cosmic rays pose additional challenges to human spaceflight (NRC, 2006), as the health threat from cosmic rays dramatically increases the chances of cancer over a decade or more of exposure (NASA, 2002). Solar flare events are rare but can give a fatal radiation dose to astronauts in minutes. Radiation can penetrate spacecraft, equipment, spacesuits, living tissue and cause both short and long-term damage to the body of astronauts. It is thought that protective shielding and protective drugs may ultimately lower the risks to an acceptable level (Jay, 2006). There is scientific concern that extended spaceflight might slow down the body's ability to protect itself against diseases (Gueguinou *et al.*, 2009). When radiation penetrates living tissue, it can cause short or long-term damage to the stem cells of the bone marrow that make up the blood and immune systems. Table 2 shows the disorders and the solutions to the effects of space radiation on astronauts.

Table 2: Disorders and Solutions to the Effects of Space Radiation on Astronauts

System Affected	• Disorder	Solution
Circulatory	• Increase of blood in the upper body	Lower Body Negative Pressure (LBNP) is needed to mechanically induce an Earth-equivalent body fluid distribution while in space
Cardiovascular	• Shift in body fluids (Jaiyeola, 2019b). Fluid redistribution cause an increase in pulmonary capillary pressure resulting to heart failure • Decrease in heart rate	The use of systems of straps and buckles to help maintain an upright position should not be underestimated
Musculoskeletal	• Bone demineralization, loss averagely 1% - 2% bone mass monthly and loses 250 mg calcium per day (Kelly, 2017) • Muscle deterioration and atrophy. Loss of muscle power, strength and alteration of muscle physiology, especially in the lower limbs (Fitts *et al.*, 2001).	Resistance exercise; dietary supplement with calcium, amino acids, and vitamins D and K. Required daily exercise to keep muscles and bones from deteriorating.
Immunological	• Immune dysregulation, which is any malfunction or improvement in molecular	Health Stabilization Program (HSP)

	control of the functions of the immune system.	
Gastrointestinal	• Change in appetite, which is any major change in eating behaviour, it is either an increase or decrease in appetite	Simulation of Earth's gravity on spacecraft can help astronauts suffering from some health challenges (NASA, 2017)

Focusing on exercise to maintain aerobic capacity with a number of techniques and devices to redistribute body fluids before landing (Thirsk *et al.*, 2009b) is quite important. Use of pressurized anti-gravity suit to minimize fluid pooling in the legs. Use of a liquid cooling garment, straps and buckles to help maintain recumbent position for astronauts on long-duration missions (Thirsk *et al.*, 2009b) should not also be underestimated.

Exercise during space flight is useful, but it doesn't fully prevent muscle loss. Other measures include: electrical muscle stimulation, and further dietary supplementation with bisphosphonates, potassium citrate, parathyroid hormone, low magnitude and artificial gravity (e.g. rotating spaceship) (Buckey, 2006a, 2006b; Oluwafemi *et al.*, 2018; Shackelford, 2008). Also, exercise (aerobic and strength) monitored and modified by on-ground medical support team is very important after return.

Health Stabilization Program (HSP) is done through an awareness campaign and procedures such as limiting access to flight crewmembers, medical screening and controlling flight crewmember's activities to alleviate the risk of occurrence of infectious diseases among flight crew (Johnston, 2010).

Antioxidants like vitamins C and A may help by absorbing radiation produced free-radicals before they will do any harm. Research has also suggested that pectin fiber from fruits and vegetables, and omega-3-rich fish oils may be beneficial countermeasures to damage from long-term radiation exposure (NASA, 2014).

III. RECOMMENDATIONS AND COUNSELLING METHODS

It is suggested that a better health care plan ought to be put in place to build awareness about: the dangers of space environment to astronauts and their physiological adjustments to long-term space travel; the pathophysiology of changes related with space environmental forces and the sickness and diseases forms; predictive, development and validation of the preventive measures, symptomatic, helpful, and rehabilitative measures for pathophysiological changes during space missions (Meleshko *et al.*, 1994).

Thanks to the much greater stream of high-energy galactic cosmic rays (GCRs), the radiation environment in deep space is distinct from the one on Earth's surface or in low Earth orbit. The hazards from cosmic rays are the threat posed to astronauts by GCR and solar-energy particles on interplanetary missions or any other mission outside Earth's magnetosphere (Schimmerling, 2011). They are one of the greatest barriers standing in the way of plans for interplanetary travel by crewed spacecraft (Chang, 2014), but space radiation health risks also occur for missions in low Earth orbit. There is always a danger of radiation, whether at low Earth orbit or during long-term missions into deep-space. Mitigation techniques, protection and enclosures should all be considered in every environment

astronaut will be in while on space mission (NASA, 2019). The followings are the counselling methods and recommendations involved in checking the effects of radiation on the physiology of astronauts:

- Shielding: Material shielding can be beneficial, but thin shielding will make the issue worse for some of the higher energy rays, while thick shielding will mitigate this effect (NASA, 2011). Shielding materials could constitute liquid hydrogen, water or asteroids.
- Drugs: The development of drugs like retinoids enhances the body's natural capacity to repair damage caused by radiation (NASA, 2011). They are vitamins with antioxidant properties and molecules that reduce cell division, giving the body time to fix damage before deleterious mutations can occur.
- Timing of missions: During times of high solar activity, radiations are relatively lower; thus, interplanetary travel during solar maximum will reduce the average dose for astronauts (NASA, 2011).
- Orbital selection: Usually, radiation exposure from the Earth's radiation belts is mitigated by selecting orbits that bypass or move through the belts relatively quickly (NASA, 2011).

IV. CONCLUSION

The hazards of the space environment are enormous from microgravity and space radiation. Considering these challenges, space organizations amongst others must increase knowledge base, deploy more balanced interventions such as use of drugs, and do more proper orbital selection and timing of space missions to target periods of lower space radiations. Other considerations include exposing astronauts on board a spacecraft to Earthly gravitational forces and daily exposure to artificial gravity was shown to be protective against adverse physiological changes associated with microgravity by the use of short-radius centrifugation.

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