

New dimensions in Architectural Construction and Engineering.

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Abstract.

The new world order is all about architecture which is sustainable, Eco-friendly and has the least impact on the environment. In consonance with this a new paradigm needs to be established wherein a holistic approach to engineering and construction is adapted. Embodied energy, carbon footprint, recycling and global warming potential become critical factors when assigning appropriate materials. Developing, infusing and amalgamating modern technology with local construction skills will define a new idiom for construction and engineering. The resultant architecture would be appropriate, acceptable, agreeable and would be synergetic with the definition of green architecture. This treatise briefly chronicles the evolution of various construction methods and engineering techniques and enumerates the various ways and means in which modern technology can be incorporated in elevating local skills and techniques. It also seeks to establish a methodical template to achieve the same. The proposed interventions are verified by calculations and/or simulations. It concludes by enumerating the various benefits of this new dimensions and reasons out how it is the way forward.

Key words. : Sustainable, eco-friendly and green architecture.

Introduction.

Our world today is developing at a frantic pace. The main reasons for this are development of technologies based on cutting edge research. This represents the vast power, capability, and ingenuity of the human mind. From the discovery of fire to the invention of the wheel, the human race has been very prolific in its quest for new materials and technologies. This treatise briefly chronicles the emergence of technologies and its influence on architecture. It also discusses and enumerates the various ways and means in which local skills can be amalgamated with modern technology to establish a new paradigm in architectural construction and engineering.

Etymology.

The word “structure” is derived from the Latin word “struere” which means “to build”. The word “construction” comprises of two words “con” which means “to come together” and “struere” which means “to build”. The word engineering is derived from the Latin word “ingeniare” which means an “inventor”. The word “dimension” is derived from the Latin word “dimensio” which means to measure. The word “Architect” comprises of two parts – “Archus” in Latin means “chief” and “tekton” in Latin means “builder”.

Chronology.

Throughout the history of mankind all research, inventions, and technologies were war based. Human aspirations for power, influence, and affluence dictated the kind and type of technologies to be researched and developed. Most of the technologies in use today are peacetime applications of technologies developed for wartime use. Every invention right from the ball point pen to AutoCAD was for wartime use.

Morphology.

The first human settlements were hamlets. A cluster of hamlets morphed into a village. A cluster of villages morphed into a town. Towns became cities which morphed into a polis. Polis then evolved into Acropolis, metropolis, and mega polis. The evolution of technology has enabled this growth. Today we are talking in terms of smart cities.

Evolution of technology.

This evolution in forms was due to the rapid pace of urbanization. This was made possible by the evolution of technology. In the beginning the pace of technology development was very slow. This was because historically there were monarchies where the king and in some cases the church were the main patrons. The main patronage was given to arts and Architecture. Scientific research was selectively encouraged. Galileo and Copernicus are a case in point. Most of the research was only fundamental research. Even these were carried out by individuals on a standalone basis. There was very little or no state patronage. It is a testimony to human perseverance that in spite of all these constraints there was tremendous scientific research work done even in these dark ages. Sir. Issac Newton, John Dalton, Robert Hooke, and many others laid the basic concepts for the fundamentals of modern engineering. The genesis of modern science

began with the Greek civilization. In fact Greece is the crucible and the incubator of all the basic fundamentals on which modern science is based. All theorems, postulates, and principles in science, arts, and architecture are based on Greek origin.

The industrial revolution in the year 1850 and the establishment of the stock market in year 1915 changed the entire scenario. Fundamental research carried out over the last couple of centuries started being put into application. This led to the development of a new discipline called engineering. Engineering was all about developing the requisite technologies based on the application of these fundamental principles. The core application of engineering was – prospecting (for valuable resources), processing (converting these resources into raw material), construction and manufacturing. The advent of steel and glass as a potential building material changed the skyline of our cities. Crystal palace by Joseph Paxton, Eiffel Tower and the statue of liberty by Gustave Eiffel was a celebration of materials and technology. Now buildings could not only go higher, they could go wider. Mass production made materials like steel, glass, and cement affordable, accessible, and available. Earlier we had buildings with only openings but no glass. Then we had buildings with small glass panes. This was not a limitation of an architect's imagination but a limitation of the material. Once Sir. Alistair Pilkington invented the technology for float glass the very face of architecture changed completely. Earlier “we had glass in a building-now we had buildings in glass”.

Urbanization.

Urbanization and technology are synonymous with each other-in fact they go hand in hand. It is the development of technology that has made urbanization possible. Cities are the incubators and nursery for technological development and growth. This is because all our best resources-including human capital are concentrated in our cities. The following example illustrates this point-If the best talents in our country converge in one place we get a Mumbai. Similarly when the best talent from all over the world converges in a place we get an America. All the best talent and resources are concentrated in cities. Cities also have a unique social structure. The social fabric of a city is very different from the hinterland. The demographic profile is very divergent and cosmopolitan. Divisions along the lines of race, color, faith, caste, and creed are minimal. They only serve an academic purpose. What matters here is performance and success. City is also able to call upon all the resources that it needs to fulfill its development needs. It can call

upon these resources anytime, from anywhere and in any quantum. All precious resources like food, water, raw material and quality human capital is diverted to a city. In return the city produces finished goods and technology. Silicon Valley in California (USA) is a classic example.

The Current Scenario.

Man today is caught in the intricate web work of his own creation. Urbanization is happening at a frantic pace. Our cities are choking and bursting at its seams. Land, water, and air pollution is at an all-timehigh. There is also a very sharp social divide – There is a rich class which is a small minority, a poor class which is a majority and an aspirational class which is a subset of the poor class. Most cities have morphed in to a metropolis-mother city. Metropolis is a magnet which attracts people from all over as it offers the best of opportunities. Cities offer quality in education and lifestyle .This has led to a mass migration to cities which in turn has led to the proliferation of a whole host of problems like slums, organized crime, and class divide. Cities today have become high density settlements .It has become a monster which consumes a humongous amount of resources. The rate at which urbanization is happening on our planet the day is not far when there will be no planet left.

Sustainability.

The ability to sustain or bear something is termed as sustainability. The rate and the manner in which we are consuming and exhausting our valuable resources is alarming. Our consumption model is not need based but greed based. The day is not far when there will be no resources left to exploit. There will be nothing left for our future generations. Unwarranted overexploitation of scarce and valuable resources has led to this situation.

Development vs. Sustainability.

This is the real conundrum today. Progress is synonymous with development. We have now reached a point where any kind and type development is unsustainable. It is the classic egg and omeletsituation. It is not possible to make an omelet without breaking the egg. It has now reached a stage where any form of progress can happen only if it is unsustainable. The challenge today is to develop a sustainable model for development in a manner in which the progress of the human race is not hampered.

The Model of Technology.

To achieve sustainable development and progress the current model of technology has to change. Our entire technology today has been developed on the basis of certain key resources. This has led to the overexploitation of these resources. Overexploitation has led to the depletion of these resources. Also as these resources are available only at select locations there is transportation involved. This in turn gives rise to a huge carbon footprint. This trend has to be reversed. Technology should be developed based on the resources which are locally available. Also these resources to be carefully and judiciously used to ensure that there is no overexploitation. Most of the resources that we harness for our technology model are natural resources. The geological timescale for the replacement of these resources could run into millions of years. The need of the hour is to therefore evolve a different technology model –one which is not dependent on natural resources. Dedicated Research in this direction is the need of the hour.

Captive Systems.

The present model of harnessing, harvesting, storing, and transporting water, power, gas, and other allied essentials has to change. Water for our cities are stored in huge dams and then transported to the required destination. The same is true for power, gas and all other resources. Thus there are three parameters involved-source, path, and destination. All our research and technology has been concentrated on making this happen. The type of technology needs to change. Technology needs to be developed wherein the required water and sources of energy like power and gas are produced, stored and use at the source itself. The path involved if any should be minimal. The destination should be as close as possible to the source itself. Research in the development of captive systems is the way forward-something which was done in vernacular architecture.

Captive Toilets.

The current types of flush toilets are neither sustainable nor affordable. They consume humongous amount of a very scarce resource –water. They also require an elaborate system of plumbing to ensure water for ablutions and flushing. An equally elaborate system is needed in place to ensure proper sanitation. The crux of the problem is that the pace and quantum of research done and technology developed for toilets is almost negligible compared to the pace of research and technology in other fields. The time has come to harness all of human ingenuity,

talent, enterprise and skill in developing captive toilet systems –systems which will use very less or no water and process its waste into something useful.

The Problem with Human Sanitation.

Cities are high density human settlements. Whether humans live in deplorable slums with no sanitation facilities or in high-rises with elaborate plumbing and sanitation systems the problem of waste disposal remains constant. Due to constant medication from birth onto death and thanks to a decadent lifestyle the human waste is highly toxic. Also humans have grown accustomed to customized washrooms. Architects and planners keep on designing and building human settlements at a frantic pace using modern technology or even customized technology to circumvent any problems. But they comfortably turn a blind eye to and ignore this basic biological issue. Quality and dedicated research to be carried out to develop suitable and appropriate technology to handle the logistics of human sanitation. Unless this is carried out on a war footing our cities will soon become cesspools. The present system also leads to a lot of hygiene and healthcare issues.

The Problem with Agriculture.

The burgeoning human population in our cities requires food. Cities do not grow or produce any food. They only consume food. They also consume humongous amount of food. The quantum of food varies as per the size and density of the city. Like everything else in a city food is also an expression of status and a lifestyle statement. Therefore the type and variety of food required is of an exotic variety. This is grown and produced in the hinterlands and processed, packaged and supplied to the cities. This holds good for all types of foods and beverages. This has a huge impact on our agricultural practices. Most of our agricultural practices are geared towards producing cash crops-coffee, tobacco, rubber etc. This plays havoc with the soil suitability and fertility. Also much of the land required for agriculture is generated by encroaching on forest land. This leads to habitat destruction which in turn results in a man –animal conflict. Research needs to be done to change and redefine the way we practice agriculture. The current model is not eco-friendly and has a huge environmental impact.

Captive Vertical Transportation Systems.

As the land to build becomes scarce cities have started going vertical. This entails vertical transportation systems like elevators and escalators. As these systems have to defy the basic laws of gravity they consume a lot of energy in their operations. Research needs to be done and technology developed to convert these systems into self-powered devices. Independent flying mechanisms could also be thought of as an alternative.

Synthetic Biology.

One of the ways forward in future is to grow your own house. This would oblivate the need for expensive foundations and also be eco-friendly. The walls and roof could act as natural bio filters and thus maintain the desired IAQ (Indoor Environment Quality.) They could also grow vegetables and fruits which are required as food by humans. Synthetic biology is a science which synthesizes all fields of engineering with biology. Its high time building construction is also integrated with biology. Many Plants have a natural flexural strength due to their fibrous composition and this aspect could be harnessed in constructing amoebic forms. Topiary is a skill which to date has been used only for visual purposes. Research should be done to develop native plants which can be grown in the form of shelters. The same logic could also be extended to other structures like bridges. Synthetic biology could also form the basis for parametric architecture.

Building in Air.

Humans are essentially terrestrial in nature. They can exist only on land. But the problem is that their need for food, clothing, and shelter has a huge land and carbon footprint. All ecosystems including terrestrial ones are linear in nature. Human presence upsets this chain and permanently damages these ecosystems. Also as the availability of habitable land is reducing wetland, salt pans, rivers, and sea are being reclaimed. This permanently damages and alters the ecology. Also the foundations of buildings and other structures permanently damage the earth's crust and to a certain extent the core. This upsets the delicate plate tectonics of the earth. The way forward would therefore be to build human settlements in air. The land footprint and damage to ecosystems would be minimal. The other advantage is that these types of structures could be independent of the terrain conditions. Technology could be comfortably developed along these lines.

Inflatable Structures.

The way forward would be to develop inflatable or pneumatic structures. These structures could comfortably float in air and only needs to be anchored to the ground. The basic technology for this is already there and it only needs to be piloted in a logical and scientific manner. This will also ensure that buildings would not need foundations. This would also help in redefining the various building elements.

Bioremediation Techniques.

Nature is supreme in its abilities. It also has its own systems for checks and balances. There are two ways to approach a problem-the natural way and the artificial way. The natural way is a biological process –it may be slow but it’s always sure and never has any side effects. More research needs to be done to discover the various natural remediation techniques and apply the same .All human health related issues could also be treated with bioremediation. Any and every kind of waste should also be treated with bio-remediation techniques. Development of appropriate biotechnology is the way forward for human race.

Self-Contained Settlements.

Presently the planning of all human settlements is planned on a rigid demarcation basis. There are commercial zones, industrial zones, recreational zones and residential zones. Besides these there are various other allied zones-special economic zones and so on. The problem with this approach is that vital resources like water, power, and gas besides a host of other utilities have to be harnessed, generated, processed, stored, transported, and supplied to the various individual units. Also the waste generated by all these settlements is just dumped in the nearest water body. This approach itself is a flawed one. The way forward is to develop settlements which are integrated so as to reduce the commuting distances. Also each settlement should be able to harness and meet its own water and power requirements and also process its own waste. The need of the hour is to have a holistic approach towards planning and seamlessly integrate the various technologies. Professionals from all disciplines need to be involved in a collaborative research to work towards a solution.

Energy.

Today we are dependent on fossil fuels like oil and coal to meet a bulk of our energy requirements. This is happening at a huge environmental cost. Technologies developed for

harnessing renewables like solar and wind is still at a very nascent stage. They are more of showpiece technologies rather than utilitarian technologies. As they have been developed and used in an isolated manner and on a piecemeal basis they are unaffordable at the moment.

Don't save on energy-Save Energy.

The way forward today is to not only to reduce the consumption of energy but develop and invent systems which require very less energy or no energy. Systems which can generate their own energy for performance are ideal systems. Therefore every system should be self-sufficient.

Zero Energy Settlements.

A settlement which produces as much energy as it consumes is known as a zero energy settlement. This should be the governing template when designing any kind and type of human settlements. This should happen at the micro level- it will then happen at the meso level and macro level. These types of settlements will reduce the carbon footprint and have less GWP. (Global warming Potential). Specific research needs to be carried out in these areas. So far architects have tried to adapt to existing technology. But now the approach has to be different. They should define the type and kind of technology they need.

Thermal Comfort Systems.

Humans are the only species which cannot adapt to any weather or climate. Their tolerance for temperature and humidity is a very small and narrowband. This is the reason they need to spend a majority of their time indoors under conditions which are suitable and acceptable. They also need PPE (personal protective equipment) in the form of clothing to help them negotiate weather and climate patterns. Development of appropriate thermal comfort systems which will work on very little or no energy needs to be developed to make spaces for humans comfortable. These systems need to be developed at a micro level, meso level and macro level. In other words dwelling units, clusters and settlements –all of them should come under this ambit.

Transparent Concrete.

Cement concrete is the most common building material in use today. It is a very affordable and versatile material. However it is a completely opaque material. Research has shown that the introduction of certain types of fiber optics in the concrete has rendered it transparent. This research should be pursued and architects must exploit this invention to bring in more daylight

into spaces. Fiber optic technology can also be harnessed to transfer daylight into deep building recesses. Research should also be done to develop storage systems for daylight.

Plastic –A Wonder Material.

Plastic is a wonder material invented by man. The generic name is PVC (Poly Vinyl Chlorides). It is lightweight, weather resistant, transparent, and affordable among the host of its qualities. It's only drawback or disadvantage is that it is not biodegradable. It is a material with great flexural strength and therefore is ideal for use as a structural member. More unbiased research needs to be done and technologies developed to use this as a building material. It is also a material which is endlessly recyclable. Also technologies especially bio-technology can address the issue of degradation of plastic. There has been no focused research on the same.

Plastic Bricks.

Every environmentalist and planner opposes plastic as it is a non-biodegradable material. But plastic has become an integral part of our existence. Waste plastic can be shred and converted into useful building materials like plastic bricks and modular panels. This will ensure that natural resources are not exploited for construction and even the issue of waste plastic disposal is taken care of. Research needs to be augmented on this front and suitable technologies to be developed.

Protected Sanctuaries.

Humans, flora, and fauna have a symbiotic intricate relationship. They are completely dependent on each other. Human waste is in the form of urine and feces. Urine is 95% water and the majority of the rest is urea which is a very good fertilizer for plants'. Feces are 75% water and a majority of the rest is NPK (Nitrogen, Phosphorous and Potassium) in a form that can be easily assimilated by plants. Plants produce food from sunlight through a process called photosynthesis. Animals are dependent on plants and other animals for their food and humans are dependent on both plants and animals for their food. This is the cycle of nature. Besides interventions like permaculture, xeriscaping and regenerative landscaping all human settlements should also be developed along the lines of a protected sanctuary. This will aid in rejuvenating the landscape and also help set up vibrant and thriving ecosystems. Humans, flora and fauna have to learn to coexist. In this entire setup it's the humans who are the problem.

Different and Bold Ideas.

The absence of an idea to find a solution is termed as a problem. To tackle the present situation one has to come out with bold, innovative, and creative ideas. There has to be a radical change in approach and thinking. Unless relevant research is undertaken and appropriate technologies developed the sixth extinction of our planet is just waiting to happen. As humans are the root cause of the problem they are responsible for the solution.

Modular Self-Contained Units.

It is pertinent today to think of developing modular self-contained, self-sustaining and zero energy modules for residential, commercial, industrial and all other allied purposes. Mass production will make these units affordable and they can be made entirely of recycled material. Simple, user friendly DIY (do it yourself) systems can be evolved for dismantling, assembling and transporting these units. Humans need not waste their time, energy, and resources on architecture and can put their talents, skills, and enterprise to better use.

Redefine Building Architecture.

Architecture as it is practiced today is useless, senseless, baseless, and meaningless. The outlook and concept of architecture has to change and evolve to be of relevance. Architecture should strive to address human issues within the matrix of sustainability, ecology, and environment. The vision that architecture has to define the landscape, look glamorous, and make a statement has to change. Instead it has to be functional, purposeful, utilitarian, affordable, sensible, and accessible. Unless this happens architects and architecture are doing more harm than good. The fundamentals of ekistics should form the guideline for architectural design. Human settlements should neither be urban or rural –they should be rurban.

Memory Materials.

Cutting edge research has established that every material has a memory. It can lose and regain its shape as directed. The use of these types of materials in buildings can evolve a new paradigm in Architecture. Building elements like walls and roofs for example can open out or retract as required. Storage spaces may be a thing of the past and transportation may acquire a different dimension. The possible use in architecture is endless and exciting. Architects need to define how they want to exploit this concept so that focused research can be carried out and the relevant and appropriate technologies developed.

Use of Desert Sand in Construction.

Sand is the most important component among all building materials. The quality that makes it irreplaceable are –it is very fine and therefore permits complete permeability. It is also inert and does not get into any sort of reaction with any material. It has a high density and therefore provides the requisite bulk. However the sand which is required for construction purposes has to be dredged from the river bed. This has a huge environmental impact and an ecological cost. Sea sand is not an option because of its high saline content. Therefore the possibility of using desert sand for construction should be examined.

Glass Concrete.

At the moment the metal or aggregate that is used in concrete and other works is obtained by quarrying. The possibility of replacing these aggregates with crushed glass should be examined. Glass has a very high compressive strength and is very hard. It is also a material which is endlessly recyclable. Waste glass could be crushed and used as aggregate. It will also solve the problem of waste glass and reduce stone quarrying.

Solar Geometry.

The primary source of all the energy on the earth is the sun. Solar radiation has two components –heat and light. Both these components need to be harnessed and harvested in our buildings. Solar geometry varies with the latitude of a place. The solar geometry should govern the location, function, activities, and the final design outcome of any space. This will reduce the dependence of the space on any other forms of energy.

Evolving and Revolving Facades.

The façade of a building is that portion of a building which has the maximum surface area exposed to the elements. As weather patterns constantly change during the day as per the annalema path of the sun the façade design should also respond to the same. The façade should evolve in size, shape and design as a response to this stimuli. As the surroundings of a building are dynamic a static façade is not a desirable response. Further facades can also revolve around the building as a response to changing weather patterns. A evolving and revolving outer skin which will harness the solar radiation absorb heat, let in light and harness wind power will

augment the thermal comfort levels in a building. Architects need to define how they want to exploit their facades.

Thermal Sensitive Envelopes.

Building envelopes in the form of walls and roofs are protection devices against the vagaries of weather and climate. They have to be designed in a proper scientific manner. They have to be climate responsive. They have to either resist heat gain or prevent heat loss. In certain cases they also have to provide the requisite thermal lag. Just like we vary our PPE (personal protective equipment's) or clothing levels as a response to weather and climate, building envelopes should be designed to do the same. Research should be focused on creating and developing these materials. Bio mimicry could play a vital role in shaping these envelopes.

STES (Seasonal Thermal Storage Systems.)

One of the main drawbacks with renewable energy systems like solar and wind is that they are available in required abundance only at particular times of the day and in particular seasons. Current storage systems like batteries are expensive and also highly toxic. The solution lies in developing passive storage system units using natural materials with high thermal capacity. This will ensure that renewables can be harnessed even during non-seasonal time. The hypocaust invented by the Romans is a classic example.

Humidity Net.

The moisture content in the air plays a vital role in defining thermal comfort. In hot and dry regions lack of humidity is the problem while in warm and humid climates it's the excessive humidity which is the cause of discomfort. Shading devices have been developed to combat temperature but nothing has been developed to address humidity. Appropriate humidity net needs to be developed which will encompass all dwelling units as well as settlements. In climates where humidity is desired it should be made of an absorbent material and in climates where humidity is not desired it can be made of a desiccant material. The humidity net will also help in improving the microclimate of a particular place. This type of net can also be

used to condense moisture from the air and generate water –especially in humid climates.

Vertical Farming.

An ever increasing population places a lot of demand for food. Each unit and each settlement should grow its own food. As land is scarce the farms need to go vertical. All biodegradable waste generated can be used as manure and waste water can be used for drip irrigation. All the produce can therefore be organically grown. Each unit or cluster settlement should only farm local and seasonal produce. It should also grow only the required quantum. The technology for all these measures is available-Architects need to synthesize this into their design solution. Drip irrigation systems can also be comfortably incorporated.

Harnessing Precipitation.

Any form of water vapor which reaches the ground by gravity is termed as precipitation. Rain, snow, sleet, hail and dew-all are various forms of precipitation. Because of the day and night cycle and the resulting temperature difference dew is definitely formed. This dew needs to be harnessed and harvested by means of dewponds. Architects need to incorporate this feature into their design.

IPM –Integrated Pest Management.

All pest control to be effected by means of IPM (Integrated pest management). This is based on the premise that in nature every insect has a predator which keeps its population in check. The entire system is based on the principles of etymology. These should be an integral part of the landscape design.

Peizo Electricity.

“Peizo” in Latin means to “push”. Certain materials under mechanical stress produce electricity. Most human activities can be converted into a form of mechanical stress and electricity can be generated. Public spaces, gymnasiums, staircases and a whole lot of spaces can be converted into generators of electricity which in turn can be stored and used for fulfilling energy requirements.

Electronics .

All mechanical systems in a building should slowly be converted into electronic systems. These systems are cheaper, safer and are environment friendly. As they do not have any mechanical parts they are easy to install and maintain. They are also light and occupy very less space. This will also ensure a reduction in mechanical devices.

Low Power Devices.

The main advantage of electronics is that they are low power devices. The consumption of electricity is very low and therefore even small amounts of electricity generated by captive systems are sufficient for their functioning.

Intelligent Buildings.

Future Structures should have elements which morph into appropriate forms as a response to weather patterns and climatic conditions. All the various systems should switch on when needed and shut off when not required. All the services and systems in a building should become smart and electronics have a huge role to play in this.

Systems Automation.

All the systems should be controlled by a microprocessor and should be able to comfortably communicate with each other. This will reduce maintenance cost and also increase the efficiency.

Focused Research-Scalar at the Moment.

Architects need to properly define what kind of research is needed. At the moment all the research done is scalar in nature –plenty of magnitude but having no proper or particular direction. Problem definition and broad outlines for the requisite research should be defined by architects. Once this happens relevant and appropriate technologies based on proper research will be developed. If we are clear about what to do then how to do it becomes much easier.

Rethinking Mobility.-Crawling Cars.

Today we modify the terrain to suit a car. It should be the other way around. The terrain should be left undisturbed and cars should be modified to suit any type of terrain. Like centipedes we can also have crawling cars. Automobile research needs to look and think beyond the conventional wheels.

No Roads.-Redefine Roads.

Roads are the biggest ecological problem today. They divide ecosystems and all development is road centric. They are also perfect black bodies which contribute significantly to UHI (urban heat island) and are also non-permeable surfaces. Architects have to design settlements without roads or minimal roads.

Vitricity.

Virtual electricity or electricity which can be distributed without any wires or cables is a reality today. Architects must promote and harness this technology in their designs to have settlements without any wires or cables.

Electricity from Algae.

Algae can be easily cultured and electricity generated from it. This technology needs to be developed and incorporated in buildings as a captive power system.

Electricity from Urine.

Human urine can also be harnessed to produce electricity. This is termed as urinicity. This can ensure that power requirements of washrooms are met in-house. This is a reliable and continuous source and its potential for producing electricity should be exploited.

Mushrooms and Fungus as Foods.

At the moment our range of food is very limited. Fungus and mushrooms are nutrient rich and certain species can be easily and conveniently harnessed to our food palette.

Malleable Materials.

Research needs to focus on developing artificial materials which are malleable and flexible. All unused and waste material should be used as a raw material. This will enable architects to experiment with more amoebic forms and bio mimicry architecture can become a reality. It will also scale down the exploitation of ores and minerals.

Greening of Deserts.

Research should be carried out on how deserts can be reclaimed back as usable land. Humans, flora and fauna need to come together to initiate this process. This is the kind and type of reclamation that we should strive for and achieve. Low density human settlements would ensure

a perfect balance between humans, flora and fauna. This process should be scientifically initiated so that in course of time we can successfully rejuvenate our planet. It would also generate land for human habitation.

Bioluminescence.

Many living creatures have a natural ability to emit light. This needs to be exploited as a source of light. This would be an environment friendly solution. It will also help in reducing light pollution.

Biodegradable Materials.-Construction and Demolition Debris.

Construction and redevelopment activities generate a humongous amount of debris. Research must be done to pulverize and recycle this into useful building material. This new material should also be biodegradable so as to have the least impact on the environment.

Task Lighting.

Allour lighting needs should be shifted to task lighting. Intelligent building systems can cater to this. This will reduce the consumption of energy and also bring down light pollution. Also technologies need to be developed to harness and store daylight for nocturnal use.

Nocturnal Lifestyle.

Humans cannot see in the dark. Much of the energy consumption happens because of our nocturnal lifestyle. A process of social engineering needs to be set in wherein there is a complete change in lifestyle. Like the generations of the yore- start your day at sunrise and end it by sunset. This itself would initiate a drastic fall in our energy consumption and also resolve a whole lot of social and cultural issues.

Biofuels.

Research should be done to cultivate and harvest more biofuels. Vertical farming should be the means adopted for this and the reliance on fossil fuels should be totally stopped. It should be ensured that only native vegetation is used to produce these biofuels.

Compact Spaces.

Indoor spaces should be designed to be more utilitarian and compact. This will reduce the energy needed for achieving thermal comfort. Also the spaces designed should be multifunctional and multiuse spaces to ensure that there are no idle spaces.

Change in material palette-increase the materials.

The number of materials available for construction should be increased so that the over exploitation of material resources is reduced. This would also give a wider palette to designers to exhibit their creativity.

Complete Waste Management.

Waste as a concept should be completely eradicated .Any and every form of waste should be reduced, reused and endlessly recycled. In fact nothing should be produced unless there is a definite roadmap of how to handle the material after its useful life. This would lead to improved hygiene in the surroundings which in turn would mean fewer healthcare.

Reduction in Consumerism.

Our entire economic model is based on consumerism. The more we consume the more affluent and developed we become. Unless this flawed concept changes we cannot really bring about any significant difference to our environment. It is consumerism which generates non-biodegradable waste.It also entails transportation of goods which contribute to a carbon footprint.

DIY Technologies for Construction.

Construction systems to be developed along the lines of simple modular DIY (do it yourself) systems. This will reduce the labor costs and make houses more affordable. Mass production of these components will also make them easily available and economical.

Regenerative Landscaping.

Scientific regenerative landscaping should be carried out on all denuded land and disturbed landscapes –abandoned quarries, mines etc. This will help restore ecosystems, increase the green cover, improve the environment quality, and also help improve the microclimate.

Constructed Wetland and Mangroves.

In its quest for reclaiming land for development the human race has eradicated any number of wetlands and mangroves. This has led to a whole gamut of natural disasters and yet we continue

to make the same mistakes with impunity. Existing wetlands and mangroves should be conserved. To the extent possible new wetlands and mangroves must be scientifically constructed. This will help regenerate the earth's ecology. This has to be done on a priority basis. Suitable technologies to be developed for the same.

Dams.

The concept of dams as a means of storing water and producing hydel power should be stopped completely. Instead a series of terrestrial captive systems for harnessing and harvesting precipitation should be scientifically worked out. Remote sensing technologies and software's like GIS (global information systems) can play a major role in aiding this.

Regenerative Architecture.

A new paradigm needs to be established in the approach to architecture design. Design has to be for the nature, with the nature and should respect nature. In nature everything regenerates and architecture should also be in consonance with this principle. Also the approach needs to be based on passive interventions for achieving the desired thermal comfort. Spaces should also be redesigned as multiuse multifunctional spaces catering to various spatial and temporal needs. There should be no idle spaces and zoning in the form of commercial, residential, industrial, and recreational should be done away with.

Architecture.

We need to redefine architecture. Architecture should not only mean buildings. It should mean the built environment and everything that goes with it. It should be purely need based and functional. It has to be sustainable and eco-friendly by default.

Vertical Forests.-Compensatory for Ground Consumed.

Although afforestation is spoken about in principle it is practically difficult to implement because it involves a large landfootprint. Every settlement should have a vertical forest in lieu of its land footprint. This will aid in carbon sequestration, act as a bio filter, and also improve the meso and macroclimate.

Carbon Sequestration.

Our present model of development has a huge carbon footprint. Systems need to be developed which will harness and harvest this carbon into some useful forms. Carbon is the most vital element for all building blocks. If this carbon can be utilized we can reduce our greenhouse gases and reduce global warming.

Space Solar Farms.

Solar farms invoke a huge UHI (urban heat island) effect on the surrounding areas thus upsetting the ecosystems. They should therefore be located in space wherein the solar radiation is also the most intense. The electricity generated can then be virtually transmitted to the earth. They can be placed like satellites above the earth. Thus thermal, hydel or nuclear power stations can be phased out.

Harnessing Metabolic Heat.

All living creatures including humans produce body heat due to their metabolism as it is an exothermic process. This heat needs to be tapped and converted into a useful form of energy. Along with human waste this heat is also a permanent resource. Everything from our clothing to building envelopes should be designed to harness this perennial form of energy.

Heat Recovery Systems.

All mechanical devices generate a lot of waste heat as a part of their operations. Systems should be developed to trap this heat and convert it into a useful form of energy. In fact recovery systems should be an integral part of the overall design. The recovered heat should be converted into energy to power the system. Once this can happen every system will only require initial energy. This should be the basic governing template for any product design including buildings.

Education.

We need to have a relook at our current model of education. Environmental aspects should form a crucial component of the education curriculum. The education model also has to be more process driven rather than be product oriented. Unless we take the future generations into confidence and make them aware of the problems we cannot enforce any type of solutions. Also we have to realize that environmental issues are neither local, regional nor national-they are global. They do not accept, acknowledge, or respect manmade geography and boundaries. The

consequences of environmental issues are therefore global. Creating the requisite awareness through education is therefore critical to the future well-being of our planet.

Bio Filters.

Every element of the building envelope should be designed as a bio filter. This will ensure that IAQ (indoor air quality) and IEQ (indoor environment quality) are always maintained. Plants should therefore be an integral part of any space. Biofilters should also be installed in various portions of a settlement to clean and filter air. This will also greatly improve the quality of our environment and reduce the need for healthcare.

Moon Path Diagrams.

Although the sun is the source of all our energy and dictates most of our life patterns the moon also has a significant role to play. The intangible portion of our life is dictated by the moon. Many of the creatures are also nocturnal and are therefore affected and guided by the position of the moon. Therefore more detailed research needs to be done on generating proper moon path diagrams and the resultant output needs to be integrated in the architectural design.

Ecumenapolis.

“Ecumenapolis” is a Greek word which means “Human settlements of the future”. This is a term which was coined by Dr.Constantine Doxiadis who founded the Institute of Ekistics in Athens, Greece.Ekistics is the science of human settlements. A proper holistic template needs to be developed for our future human settlements. We need to clearly outline how we are going to develop our settlements in a manner which is sustainable, eco-friendly and will have the least impact on the environment. To effectively do this we also need to involve professionals from all other field to arrive at a practical and viable solution.

Technology.

We need to develop systems of mathematical modeling and simulations which will enable us to holistically evaluate our designs. This way we will be able to assess how we can make our designs more effective. More sources of energy need to be identified and the technologies developed to harness the same. At the moment all our technology is being developed in an isolated manner.

Conclusion.

We need a fresh approach to address our future. The concentration should be more on pure science and fundamental research than on only developing technology. We are still following the fundamental principles which were laid down by our earlier civilization. Our current model of research, technology, and architecture is not sustainable. Our architecture needs to be more sensitive, humanitarian and research based. It needs to evolve beyond form and aesthetics. Our development model has to be sustainable, eco-friendly and have the least impact on the environment. For this to effectively happen our building footprint should be reduced. The measures proposed here are only suggested outlines. Extensive and exhaustive research needs to be done on each of the points raised and that should form the basis for all future solutions. All the technologies available today are peacetime applications of war oriented research. We should now concentrate on doing research and developing technologies purely for peacetime use. Unless the human race makes this change in its mindset it is very difficult for anything effective to happen.

We have to realize, acknowledge, and accept the fact that “The earth does not belong to us-we belong to the earth”. Unless we change the way we live we may not be able to live. If we do not worry about our future we may not have any future.

The Way Forward.

The way forward is very simple. We have to accept, agree, and acknowledge that there is a very serious problem on hand. Next we need to concentrate all our talent, skills, enterprises, and resources in sincerely working towards a solution.

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