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ANALYSIS OF CAUSES OF URBAN HEAT ISLAND AND RECOMMENDATIONS FOR THE CONSTRUCTION INDUSTRY

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Abstract

We are all familiar with the fact that Cities are almost always hotter than the surrounding rural area and global warming ads even more heat to it and make it worse. Because of this warmth, a city may be referred to as an urban heat island (UHI).In future, the combination of urbanization and climate change could raise urban temperatures to levels that threaten human health, strain energy resources, and compromise economic growth. One of the key partners who contribute to this threat is the civil industry by covering most of the soil space with buildings and rigid pavements which are inevitable to meet the needs of growing population in countries like India. This paper mainly aims to propose general recommendations for construction industry in metropolitan cities to reduce the impacts of UHI.

Key Words – Urban Heat Island (UHI); Global Warming; Soil Space; Construction Industry

I.INTRODUCTION

The local temperature is one of the major climatic elements to record the changes in the atmospheric environment brought about by industrialization, increasing population and massive urbanization. No doubt, industrialization and urbanization improves our material lives and comfort; however, many problems are induced by these processes such as urban heat islands, global warming, air pollution, etc., Urban Heat Island (UHI) is considered as one of the major problems in the 21st century posed to human beings as a result of industrialization and urbanization. The phenomenon of urban heat islands is recognised as a direct consequence of urbanisation. Incessant urbanisation increases land surface temperatures and, over time, the city ends up as an island of heat. Scientists expect urban heat waves to increase in both frequency and intensity as cities in developing countries grow. The [urban heat island] effects are directly related to and worsened by climate change, where it is expected that an increase in the average temperature will have a stronger effect on the health of people living in cities, and particularly of the vulnerable groups like the sick and elderly.

II.IMPACT OF THE URBAN HEAT ISLAND EFFECT

The need of the hour is to control urban sprawl and put in place stringent policies for sustainable urbanisation. The mass scale deforestation, the reduction in the green cover, the increase in the built-up land, the use of materials like concrete, asphalt, tar, etc. have significantly altered the energy balance of the urban area often causing the temperature to reach relatively higher value than

its surroundings. Artificial urban surfaces such as concrete and asphalt act as a giant reservoir of heat, absorbing it in the day and releasing it at night. Pollutants from nose-to-tail traffic add to the heat and, in a vicious cycle, people turn to air conditioning, which pumps out yet more heat and pollutants, so increasing climate-changing emissions, which lead to warmer global conditions. The stress imposed by high temperatures may lead to sickness and increases the mortality rates are some of the few ill effects of urban heat islands. The deterioration of the living environment, increase in the cooling energy requirements and summer season demand for electricity increases in tropical cities and urban heat island magnifies this demand and more energy is used for indoor cooling. As energy consumption is a major source of greenhouse gases, the concentration of greenhouse gases increases with intense use of energy which leads to climate change.

III.CONTRIBUTION TO UHI FROM CONSTRUCTION INDUSTRY

The construction industry has a significant impact upon the environment throughout the world. All construction sites generate significant levels of heat from concrete, cement, wood, stone and silica, which contributes to Urban Heat Island and changing all natural lands in to built up area increases temperature of the place. But this could not be avoided also because of the population growth in developing countries. It is a problem that is becoming more pressing with every passing day, and it is obviously up to Construction companies within the industry to find ways of minimising this impact.

IV.METHODOLOGY USED

This paper aims to analyse the causes of Urban Heat Island and find how much the construction industry contributes to the UHI effect. Also recommendations for the construction industry which when adapted can reduce the impact of urban heat island effect over the area .The Methodology followed is

- Collecting responses from the people through semi structured interviews
- Formation of fault tree for the Urban Heat Island effect
- Evaluation of fault tree to identify the contribution of construction industry to UHI
- Results and recommendations for the construction industry

V.FAULT TREE ANALYSIS

Fault Tree Analysis is invented during 1962 in USA and it is a technique which is used to find the root causes of the problems that happened during execution of work and also can predict the causes for the problems that might occur in the future. It is a top down approach starting with the problem and ends with the basic events that might caused the top problem. It is helpful to find the logical relationships between the problems and the basic events. FTA includes the formation of fault tree from the details of the past experiences or records about the problem and evaluation of the tree using any of the convenient method.

Development of Fault Tree

- For our study, Fault tree was developed as below using the input from the people from the areas of urban heat islands.

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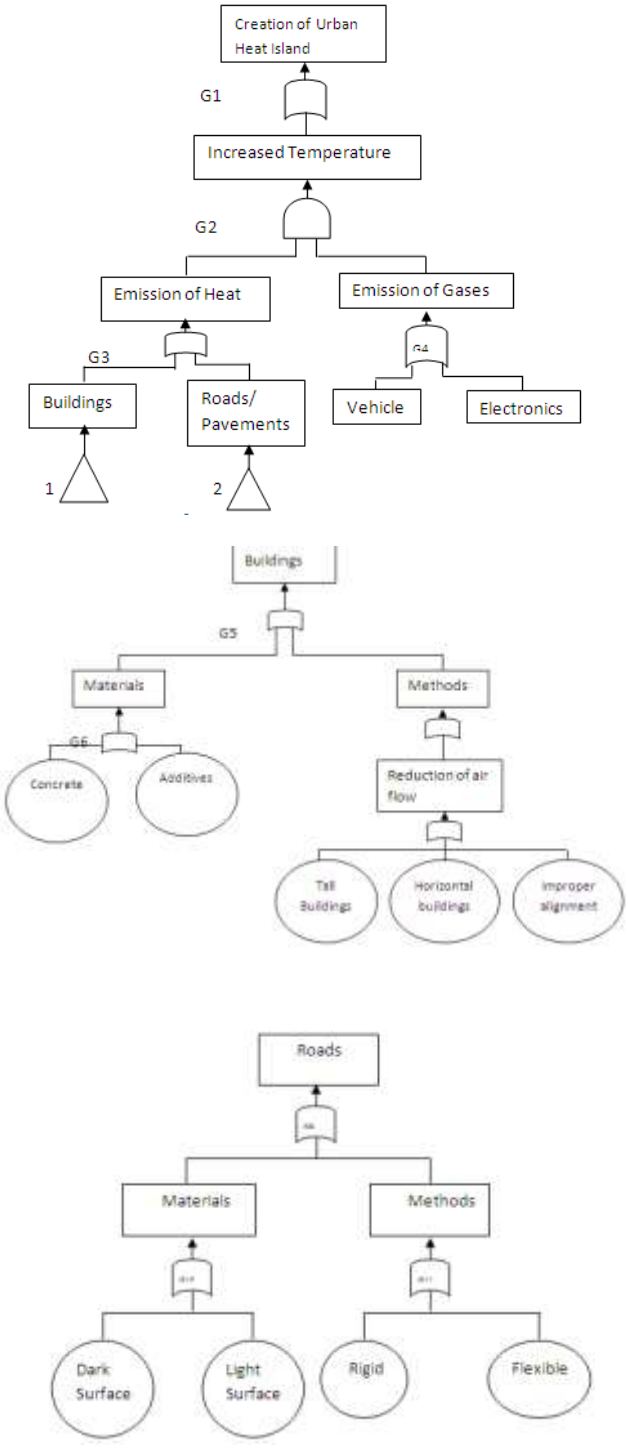

There are about one AND gate and 10 OR gates used in this scenario.

Fault Tree Evaluation

Fault tree thus developed should be evaluated to get the probability of occurrence of the top event.

Probability Calculation

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The probability of all the events should be calculated before the evaluation of the risks associated with the events. It is calculated with the below formula by assuming that the events follow Poisson distribution.

$P(X= x) = (e-\mu * \mu x)/ x!$

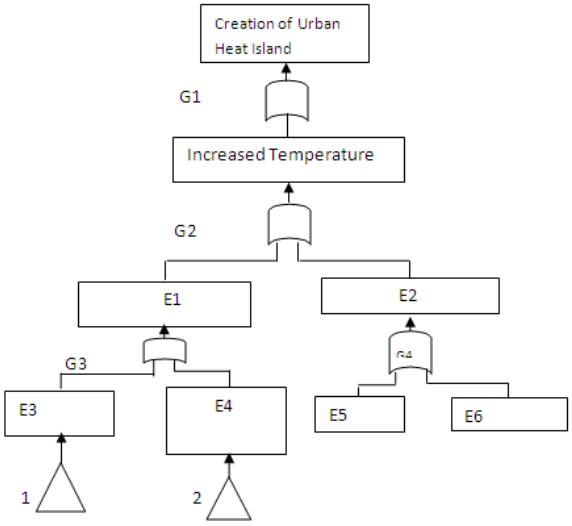
With the inputs from the survey the probabilities of the basic events are calculated by using the above equation.

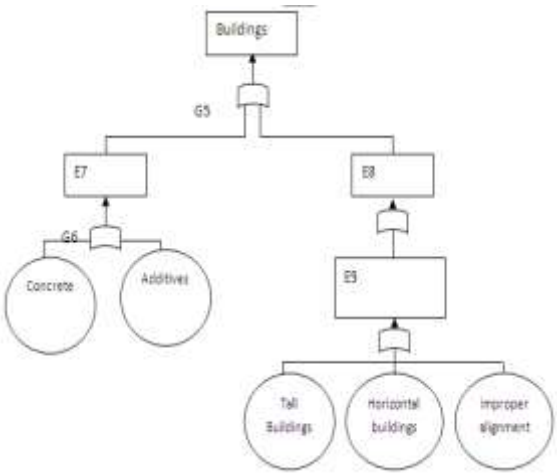
P (Concrete) = 4.05 * 10-11%, P (Additives) = 0.26%,P (Tall buildings) = 1.4%,

P (Horizontal) = 7.32%, P (Alignment) = 3.36%, P (Dark) = 1.48%, P (Light) = 0.64%

P (Rigid) = 1.489%, P (Flexible) = 3.36%, P (Vehicles) = 0.045%, P (Electronics) = 0.045%

Quantitative analysis is used to forecast the future and it uses the probability values for the calculation. (OR gate is similar to union; therefore addition of probabilities gives the probability of the event) For calculation, the above fault tree can be named as below.





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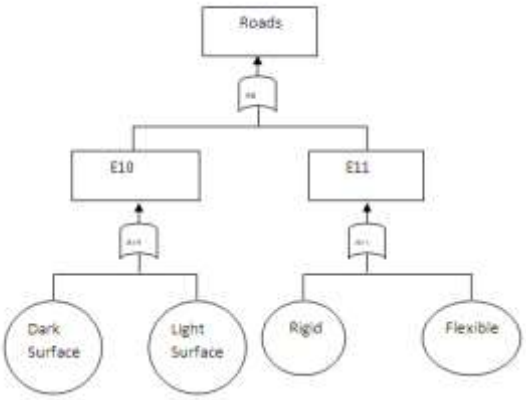

P (E7) = P (concrete) + P (Additives)
P (E8) = P (E9) = P (Tall) + P (Horizontal)
+ P (Alignment)
P (E10) = P (Dark) + P (Light)
P (E11) = P (Rigid) + P (Flexible)
P (E3) = P (E7) + P (E8)
= 0.002684 + 0.1218 = 0.1245
P (E4) = P (E10) + P (E11)
= 0.0212 + 0.0485 = 0.0698
P (E1) = P (E3) + P (E4) = 0.1943
P (E2) = P (E5) + P (E6) = 0.000908

So, P (Top Event) = P (E1) + P (E2) P (Top Event) = 0.1245+ 0.000908 = 0.1952

This Value **19.5 %** represents the probability of change in temperature by 1 degree Fahrenheit.

VI.RESULT AND RECOMMENDATIONS

The result from Fault tree analysis and fault tree evaluation show that the major cause for the issue is Dark surface- Asphalt Pavement and there is a probability of change in temperature by 1 degree Fahrenheit.

It is high time that Construction industry have to take some action to prevent being a cause to the urban heat island effect .They have to become aware of the cause and effect of the UHI and adopt simple ways that can keep living atmosphere free from killing temperature. The incomplex recommendations for the Civil Engineering industry are as follows:

- Improvement of land use- Construction of large-scale parks and green spaces, and reorientation of industrial or commercial facilities.

- Maintenance and improvement of parks and green spaces can decrease.
- Greening of streets, Greening of dwellings, Greening of buildings.

- Adoption of water-retentive materials.
- Improvement of the orientation of buildings.
- Conversion of small rivers into open channels and Construction of ponds in parks.
- Creation of eco-energy cities -Cascade use of energy, and organic integration of energy use in industrial and private sectors.
- Improvement in the reflectivity and water-retentivity of paving materials.
- Adoption of colour and permeable paving materials. Pavements cover almost 45% of the city's surface area. Most of the paved street and parking lots are paved using dark asphalt which absorbs a lot of solar energy and hence contribute in increasing the urban heat island effects.
- Introduction of traffic-control measures. Traffic demand management and introduction of low emission vehicles.
- Light colour walls and highly reflective roofing Materials-Green Roofs especially.
- Optimal operation of air conditioning systems. Increased human discomfort leads to people opting for cooling devices such as water coolers and air conditioners.

- Improvement in the heat insulation and thermo-shield of buildings.
- Reduction in anthropogenic heat release (reduction and substitution) - Artificial lighting inside the building should be avoided as much as possible because halogen and incandescent bulb produce significant heat which is absorbed by the walls and materials present in the building.

If definitely these Mitigation recommendations are taken in to consideration, then Construction Industry won't be a contributor to the UHI effect. Definitely support from Government is also required to put these recommendations in to action.

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