Effect of Structural Heat Insulation on Energy Saving and Air Pollution

Yucel, K. T.¹, Ozel C.², C. Ocal³

¹ Süleyman Demirel University, Faculty of Architectural & Engineering, Civil Engineering Department, Division of Structure, 32260 Isparta/TURKEY, kyucel@mmf.sdu.edu.tr
² Süleyman Demirel University, Technical Education Faculty, Construction Education Division West Campus 32260 ISPARTA/ TURKEY, cozel@tef.sdu.edu.tr
³ Süleyman Demirel University, The Inst. of Sciences Civil Eng. Department Division of Structural Eng., 32260 Isparta / TURKEY, cocal@mmf.sdu.edu.tr

Abstract

Heat energy consumed at structures in order to provide comfort not only cannot recycled into economy, but also be harmful by polluting air at long term. Organic fuels used in order to be warm makes environment more or less dirty. Increasing air pollution with technological developments results Greenhouse Effect. With the result of this, world is effected as increasingly being hot. Also service life of structural elements is badly affected from high heat differences. When the same comfort level is provided with using less polluting and less consumed efficient energy types, individual, society and country will provide advantage and environment will be more suitable for life. In this study expanded polystyrene, whose heat conductivity coefficient is determined, needed insulation thicknesses are calculated in order to use them together with brick elements made of Pumice. With the help of these exterior wall stratums, quantity of energy saving, decreases in air pollution quantity and heat loss of an example building are examined. It is seen that, At the Pumice brick and EPS used buildings, corresponding to non-insulated buildings; up to 66% energy saving may occur at fuel consumption in order to grow warm. At the parameters of air pollution, with the result of less fuel usage, those much low values will occur.

Key Words: Heat insulation in buildings, energy saving, air pollution, architectural details

1.0 INTRODUCTION

Air pollution is said that, the situation of materials that does not exist in the air normally (gaseous or particle materials exhausted by kinds of chemical processes) or related with increase in the quantity of materials in the air normally are not harmful, affect living beings’ lives and health negatively, brings about to give rise to cause physical harm and economic losses [1]. Some of these materials affect the lives of living beings directly whereas others affect indirectly. Concentrated-solutions of pollutants and time of exposure to those are effective factors. Generally, high concentration and short time, low concentration and long time can make the same effect to lives of living. Air pollutants are classified according to their properties and origins [2]. Generally air pollutants can be classified as: First degree air pollutants; Dust (Particle Materials), sulphur dioxide and Nitrogen oxide whereas Second Degree air pollutants;
Hydrocarbons, Carbon monoxide, Heavy Metals (Lead, Zinc, and Cadmium), Hydrogen fluorine, Hydrogen Chloride and others [3].

Generally, impurity levels of cities are determined according to their SO2 concentrations. According to this, impurity levels can be examined in three groups;
• Continuous air pollution effect: City of long time limit value (LTLV) exceeds 150 mg.m\(^{-3}\),
• Effect of air pollution in a time interval: City of short term limit value (STLV) exceeds 400 mg.m\(^{-3}\),
• Being no problem of air pollution: Cities of contaminant concentration is less than 100 mg.m\(^{-3}\) in winter [4].

2. Some Negative Results of Air Pollution

2.1. Gases causative Greenhouse Effect

Actually CO2 can not be classified as contaminant because of its properties. CO2 gas which is a compound of atmosphere has a duty of one direction filter. Contrary to the fact that sun rays reach earth surface without meeting an obstacle, when reflected as infrared rays from the earth surface to the space, some of their energy is catched with CO2 molecules and with the result of this, heat increases at the lower layers of atmosphere and in this way, heat of earth surface stays about 15 °C. Because of the fact that glass or plastic covers of greenhouses also cause the same effect, this event is named as Greenhouse Effect (Figure 1). Specialists are calculating that; today, heat of earth surface is about 3 °C warmer from the ice age and velocity of this increase is much higher in the past recent 20 years [2].

![Effectiveness percentages of gases causative to Greenhouse Effect](image)

Figure 1. Effectiveness percentages of gases causative to Greenhouse Effect [5].

As seen in the Figure 2, there is a great effect of energy consumption on formation of CO2. It is seen here that, production of electric is the first, and the others are at more or less the same value.

In order to decrease large quantities of CO2 exhausted to nature, energy that is used in buildings have to be conserved. To achieve this, heat isolation has to be applied to exterior walls and roofs, moisture insulation has to be performed, cracks has to be prevented, connection points and windows has to be designed well. To perform new structural designs and to develop new life ambiences, everybody has to notice these points [6].
2.2. Acid Rains

There is more or less quantity of sulphur in the compounds of all fossil fuels. When combustion takes place, this sulphur also burns and goes to the atmosphere by becoming sulphur dioxide. This gas, that may become a problem to human health, falls to earth surface as rain drops by interacting with the moisture at the atmosphere changing into sulfuroz and sulphuric-acid. Acid rains and decrease in the pH value of waters are the result of this situation. [2].

2.3. Direct Harm to Human Health

By the side of those above given contaminants result of burning solid, liquid and gaseous fuels that has a very fast spreading capacity, various quantities of nitrogen oxides, carbon monoxide, hydrocarbons, chlorine, halogen compounds, polycyclic organic materials and particular materials spread atmosphere according to the kind of fuel and burning process. In addition to these, with the result of burning process, the moisture in the fuels are exhausted to atmosphere coming together with the burning-residual-products; sulphur dioxide, carbon dioxide and particular materials resulting a hazardous contaminant for human health declaratory as smoke + fog [2].

3. Causes of Air Pollution

Causes of air pollution can be examined in two groups. These are;
1. Air pollution originating from fuel consumption for heating purposes; Causes related with heat savings and insulation, fuels and burning systems.
2. Air pollution originating other than heating purposes; Air pollution originating from immigration, urbanization, industry, vehicles, audit, amount of green fields, mistake measurements, public opinion unconsciousness [1].

In this study, air pollution originating from fuel consumption for heating purposes and protection against them will be examined in the example of city Isparta.

It can also be seen from the Figure 3 that, the biggest part of the energy consumed in Turkey is consumed at houses. It is more considerable that, this consumed quantity is equal and even larger than the quantity consumed at Industry. With the energy consumed at industry, contribution to national economy and individuals whereas, the energy consumed at building sector is consumed wholly only for comfort.

![Figure 3. Distribution of final energy consumption according to sectors [8].](image)

When we subtract energy consumed for other needs like lightening, hot-cold water, construction of building and usage of home devices from energy consumed at houses, we see that the energy consumed in order to make houses warm is 60 % of total energy consumed [9]. This percentage shows that, the percentage of it in our country’s total energy consumption is a big value like 21 %.

The most important cause of being energy consumed for heating purposes that much high is, enough importance to heat insulation at buildings is not paid attention and, lower heat quantity fuels are consumed in order to be warm because, they are cheap. As seen in Figure 4 that, fuels consumed in Turkey for heating purposes are wood, petroleum, coal, wastes of animals and plants, and natural gas. Natural gas consumption in Turkey which has a high heating value and low polluting is at very low level. This means that, the most important cause of air pollution originating from heating purposes is consuming fuels that have harmful material percentages high.

![Figure 4. Percentages of consumptions of fuels consumed at houses in Turkey [10].](image)
The relation between production and consumption of energy according to years and kinds is shown in Figure 5. Besides, studies on using nuclear, sun and wind like energy sources in Turkey is being investigated. But today, production is not achieved on an efficiently way.

![Figure 5. Primary energy production and consumption [11].](image)

5. Preventions for Air Pollution Causing from Fuel Consumption for Heating Purposes

In order to decrease quantity of air polluting materials resulted from consumption of fossil fuels for heating purposes, 3 methods are valid as below.

5.1. Precautions Related with Fuels

It is doubtless that, increase in quality of fuel will result an important decrease in concentration of contaminants. Whichever fuel type is used, fuels are more or less has a contaminant property as can be seen from Table 1. But if fuel quantity may be decreased and if the minimum fuel needs may be met by quality fuels, then we can met our needs with making less harm to nature. Besides, because of the fact that our country meets our energy consumption needs (Figure 6) with importation, changing type of fuel will not solve the problem, but will only result in the transform of the figure.
Table 1. Emission values for unit energy production.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Emission Quantities (mg.kcal⁻¹)</th>
<th>TEP Fuel’s Impureness Value [13] (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SO₂</td>
<td>NOₓ</td>
</tr>
<tr>
<td>Coal Rock¹² (Coal¹³)</td>
<td>2.10</td>
<td>0.42</td>
</tr>
<tr>
<td>Fuel-Oil</td>
<td>2.04</td>
<td>0.75</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0.01</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Figure 6. Distribution of imported energy according to sources in 1998 [8].

5.2. Preventions about Burning System

Evaluating heating system alternatives shows that fuel types at heating finances are more affected from heating system type. When cost of heating is examined, it can be seen that, fuel types are more effective than heating system types. In today’s conditions, block or regional heating systems are more appropriate from the economic point of view.

According to the State Statistics Institute data of year 2000, stove heating systems are weighty in city Isparta heating systems (Figure 7). Interior of buildings, flat central heating and central heating systems are being used at educational and cultural buildings.

Figure 7. Quantity of buildings according to the aim of usage and system of building heating [14].
Preventions that can be taken about burning systems can be arranged in order below;

1. Increasing caldron and stove efficiency,
2. Decreasing dust and CO₂ emissions spreading from caldrons and stoves,
3. Developing combustion and burning systems, giving related educations,
4. Doing Filtration at flame chimneys of caldrons and stoves.

5.3. Preventions Related with Heat Economy and Isolation

As can be seen in the figure 8 that, most of the structures in the city of Isparta are brick masonry buildings. Even if in the recent years new construction techniques developed and this percentage decreased, there are still lots of old buildings. Usage of not hollowed bricks is widespread for brick masonry buildings whereas, usage of hollow factory bricks is widespread for framed buildings. As the result of using brick which has a low heat isolation property, there are higher values at fuel consumption for heating purposes and related with this, in the air pollution.

Not only heat insulation property, but also elastic, resistant to wind, rain, ultraviolet rays, alkali, fungus materials has to be used in the exterior walls that have direct touch with climate [15]. Besides, degree of expansion in structural element and economy of energy has to be taken care in heat insulation [16]. Energy saving reaching %60 may be provided by using appropriate material for heat insulation purposes according to the material used and the isolation system [17].

Figure 8. Structural system of buildings and used construction materials in Isparta region are above [14].

Because of these, in order to decrease air pollution originated from fuel consumption for heating purposes in the city, alternatives from 5 different types and sizes of light-weight blocks that have specific density 0.7-1.0 kg.m⁻³ [18], heat conductivity value 0.17-0.26
kcal.mh°C⁻¹ with layers of EPS that have properties of 10-30 kg.m⁻³ density and heat conductivity value 0.039-0.030 Kcal.mh°C⁻¹ are tried with each other in combination. At the end of experimental studies, it is understood that 15~66 % of heat losses can be prevented by using these combinations [19].

When fuel consumption for heating purposes that much decreases in winter, it is probable that, nearly that much decrease in air pollution will occur.

Average of ten years of smoke and SO₂ values from 1990 to 1999 got from People Health Laboratory of Isparta is given in Figure 9 and 10 [20]. It is informed that, according to Private Representative of United Nations Joltio Espino, it is harmful to be present one hour in an ambience of 50 µg SO₂ in m³ air, or to be present ten minutes in an ambience of 500 µg in one m³ air [21].

Heating needs are in-between periods October and March. The maximum value of air pollution in the period between April to September is because of humans, vehicles, factories and consumptions other than air pollution originated from fuel consumption for heating purposes.

Figure 9. Average of ten years measured smoke values of city Isparta and the decrease that will occur when buildings will be isolated for heat.
Figure 10. Average of ten years measured SO$_2$ values of city Isparta and the decrease that will occur when buildings will be isolated for heat.

6. Results and Discussion

It can be understood easily that, 2/3 of energy consumed for heating purposes in houses can be not used. This means that, we can be warm in comfort by consuming 1/3 of the energy today used. An important result of consuming this excess energy is, the air pollution that started at bigger cities of Turkey, now threading all cities of Turkey.

It is doubtless that, in order to prevent air pollution originating from heating purposes, there lots of way and effect. The most effective way in short term is, to decrease the quantity of energy consumed by isolating existing buildings (rehabilitating) and by developing effective layering alternatives at newly constructed buildings. Other alternatives are the energy types that are not available in Turkey today or, the technologies today not developed enough in Turkey today. If we can run these studies in complete process, than we can find changeover solutions to these problems. But being the energy consumed in housing sector is greater than the one in production (industrial) sectors, show the first point of intervention in Turkey.

References


7. Özişek, M. N., “Reduction of CO₂ Emission exhausted to atmosphere by Isolating Installations of Industrial and Mechanic Type” *World of Isolation* (1999), 18, 31-36, TURKEY. (in Turkish)


12. İpek, O. and Karakoç, M., “Analysis of Using Natural Gas in Isparta from Energy, Environment and Economic points of view” *Air Pollution and Natural Gas in Isparta 97, Turkish Chamber of Machine Engineers – Department of Antalya – Agency of Isparta*, (1997), 143-151, Isparta, TURKEY. (in Turkish)

13. Fişek, S. and Selbaş, R., “Importance of Usage of Natural Gas in Isparta in order to Prevent Air Pollution”, *Air Pollution and Natural Gas in Isparta 97, Turkish Chamber of Machine Engineers – Department of Antalya – Agency of Isparta*, (1997), 183-198, Isparta, TURKEY. (in Turkish)


